boora architects

Project Manual

EARLHAM COLLEGE SCIENCE COMPLEX
PHASE 2

Conformed Set

February 28, 2014

Volume 2

720 SW Washington, Suite 800
Portland, Oregon 97205
503-226-1575
503-241-7429 (fax)

www.boora.com

CONFORMED SET
PROJECT MANUAL

EARLHAM COLLEGE SCIENCE COMPLEX
PHASE 2

February 28, 2014
Project Number 12009

Owner
EARLHAM COLLEGE
801 National Road West
Richmond, IN 47374-4095
Ph 765-983-1745
Darrell Shepherd, Capital Projects Manager

Civil Engineer
KRAMER & ASSOCIATES
101 N. Barron
Eaton, OH 45320
Ph 937-456-1332
Douglas Kramer, President
Bradley Kramer

Landscape Architect
BROWNING DAY MULLINS DIERDORF
626 North Illinois Street
Indianapolis, IN 46204
Ph 317-635-5030
Barth Hendrickson, Principal/Vice President
Jon Hutslar, Associate

Sustainability Consultant
BROWNING DAY MULLINS DIERDORF
626 North Illinois Street
Indianapolis, IN 46204
Ph 317-635-5030
Daniel Overbey

Audio Visual/Telecom/Security
DESIGN27
740 E. 52nd Street, Suite 6
Indianapolis, IN 46205
Ph 317-536-8000 ext. 11
Matthew Connolly

Acoustics
THRESHOLD ACOUSTICS
53 West Jackson Blvd., Suite 815
Chicago, Illinois 60604
Ph 312 386 1400
Carl Giegold. Partner
John Strong

Architect
BOORA ARCHITECTS, INC.
720 S.W. Washington St., Suite 800
Portland, OR 97205
Ph 503-226-1575
Fax 503-241-7429
Amy Donohue, Principal in Charge
Calvert Helms, Project Manager
Christopher Almeida, Project Designer
Stephen Endy, Project Architect
Mike Manzi, Specifications

Associate Architect
LWC INCORPORATED
4440 Garwood Place
Richmond, Indiana 47374
Ph 765-966-3546
Sam Puterbaugh, Construction Administrator

Structural Engineer
HALVORSON AND PARTNERS
600 West Chicago Avenue, Sutie 650
Chicago, IL 60654
Ph 312-274-2413
Fax 312 274 2401
Carrie Warner, Associate Principal

Mechanical/Electrical/Plumbing Engineer
dbHMS
303 W Erie Street, Suite 510
Chicago, IL 60654
Ph 312-915-0557
Fax 312-915-0558
Sachin Anand, Principal
Roy Sears, Senior Mechanical Engineer
Yogesh, Maniar, Senior Electrical Engineer
David DeBord, Senior Plumbing Engineer
Jennifer Curtis, Senior Lighting Designer
Mark Mannarelli, Plumbing Designer

TABLE OF CONTENTS

VOLUME 1

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

END OF DOCUMENT

COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
1. Piping materials and installation instructions common to most piping systems.
2. Mechanical sleeve seals.
3. Sleeves.
4. Escutcheons.
5. Grout.
6. Fire-suppression equipment and piping demolition.
7. Equipment installation requirements common to equipment sections.
8. Painting and finishing.
9. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for rubber materials:
1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:
1. Mechanical sleeve seals.
2. Escutcheons.

B. Welding certificates.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Fire-Suppression Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for fire-suppression installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for fire-suppression items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 21 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 21 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining CPVC Plastic Piping: ASTM F 493.

2.4 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
1. Available Manufacturers:
a. Advance Products and Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.

d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.5 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.6 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
1. Finish: polished chrome-plated.

C. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

D. Split-Plate, Stamped-Steel Type: With concealed hinge,and chrome-plated finish.

E. One-Piece, Floor-Plate Type: Cast-iron floor plate.

F. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.7 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 21 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
   1. New Piping:

      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
      c. Insulated Piping: One-piece, stamped-steel type with spring clips.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
      e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
      f. Bare Piping at Ceiling Penetrations in Finished Spaces One-piece or split-casting, cast-brass type with polished chrome-plated finish.
      g. Bare Piping at Ceiling Penetrations in Finished Spaces Split-plate, stamped-steel type with concealed hinge and set screw.
      h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
      i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed or exposed-rivet] hinge and set screw or spring clips.
      j. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
      k. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
      .

M. Sleeves are not required for core-drilled holes.

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

   2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
   3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
      a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
      b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
      c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
   4. Seal space outside of sleeve fittings with grout.
   5. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
   1. Install steel pipe for sleeves smaller than 6 inches in diameter.
   2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
   3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

S. Verify final equipment locations for roughing-in.

T. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 21 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.

3.3 PAINTING

A. Painting of fire-suppression systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.4 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor fire-suppression materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.5 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor fire-suppression materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.6 GROUTING

A. Mix and install grout for fire-suppression equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.
D. Avoid air entrapment during placement of grout.
E. Place grout, completely filling equipment bases.
F. Place grout on concrete bases and provide smooth bearing surface for equipment.
G. Place grout around anchors.
H. Cure placed grout.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following fire-suppression piping inside the building:
   1. Wet-pipe sprinkler systems.
   2. Dry-pipe sprinkler systems.

B. Related Sections include the following:
   1. Division 10 Sections "Fire Extinguisher Cabinets" and "Fire Extinguishers" for cabinets and fire extinguishers.
   2. Division 22 Section "Facility Water Distribution Piping" for piping outside the building.
   3. Division 28 Section "Fire Detection and Alarm" for alarm devices not specified in this Section.

1.3 DEFINITIONS

A. CPVC: Chlorinated polyvinyl chloride plastic.

B. CR: Chlorosulfonated polyethylene synthetic rubber.

C. High-Pressure Piping System: Fire-suppression piping system designed to operate at working pressure higher than standard 175 psig.

D. PE: Polyethylene plastic.

E. Underground Service-Entrance Piping: Underground service piping below the building.

1.4 SYSTEM DESCRIPTIONS

A. Combined Standpipe and Sprinkler System: Fire-suppression system with both standpipe and sprinkler systems. Sprinkler system is supplied from standpipe system.

B. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.

C. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. Opening of sprinklers releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into piping and discharges from opened sprinklers.

1.5 PERFORMANCE REQUIREMENTS

A. Standard Piping System Component Working Pressure: Listed for at least 175 psig.

B. Fire-suppression standpipe system design shall be approved by authorities having jurisdiction.
   1. Minimum residual pressure at each hose-connection outlet is the following:
      a. NPS 2-1/2 Hose Connections: 100 psig.
   2. Unless otherwise indicated, the following is maximum residual pressure at required flow at each hose-connection outlet:
      a. NPS 1-1/2 Hose Connections: 100 psig.

C. Fire-suppression sprinkler system design shall be approved by authorities having jurisdiction.
   1. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
   2. Sprinkler Occupancy Hazard Classifications:
      a. Building Service Areas: Ordinary Hazard, Group 1
      b. Electrical Equipment Rooms: Ordinary Hazard, Group 1
      c. General Storage Areas: Ordinary Hazard, Group 1
      d. Libraries, Except Stack Areas: Light Hazard
      e. Library Stack Areas: Ordinary Hazard, Group 2
      f. Mechanical Equipment Rooms: Ordinary Hazard, Group 1
      g. Office and Public Areas: Light Hazard

h. Plastics Processing Areas: Extra Hazard, Group 2
i. Restaurant Service Areas: Ordinary Hazard, Group 1

3. Minimum Density for Automatic-Sprinkler Piping Design:
   a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area
   b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area
   c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area
   d. Special Occupancy Hazard: As determined by authorities having jurisdiction.
4. Maximum Protection Area per Sprinkler: Per UL listing.
5. Maximum Protection Area per Sprinkler:
   a. Office Spaces: 225 sq. ft
   b. Storage Areas: 130 sq. ft.
   c. Mechanical Equipment Rooms: 130 sq. ft.
   d. Electrical Equipment Rooms: 130 sq. ft.
   e. Other Areas: According to NFPA 13 recommendations, unless otherwise indicated.

6. Total Combined Hose-Stream Demand Requirement: According to NFPA 13, unless otherwise indicated:
   a. Light-Hazard Occupancies: 100 gpm for 30 minutes.
   b. Ordinary-Hazard Occupancies: 250 gpm for 60 to 90 minutes.

D. Seismic Performance: Fire-suppression piping shall be capable of withstanding the effects of earthquake motions determined according to NFPA 13 and ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."

1.6 SUBMITTALS

A. Product Data: For the following:
   1. Piping materials, including dielectric fittings, flexible connections, and sprinkler specialty fittings.
   2. Pipe hangers and supports including seismic restraints
   3. Valves, including listed fire-protection valves, unlisted general-duty valves, and specialty valves and trim.
   4. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other pertinent data.
   5. Hose connections, including size, type, and finish.
   6. Hose stations, including size, type, and finish of hose connections; type and length of fire hoses; finish of fire hose couplings; type, material, and finish of nozzles; and finish of rack.
   7. Monitors.
   8. Fire department connections, including type; number, size, and arrangement of inlets; caps and chains; size and direction of outlet; escutcheon and marking; and finish.
   9. Alarm devices, including electrical data.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Fire-hydrant flow test report.

D. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations, if applicable.

E. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13 and NFPA 14 Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."

F. Welding certificates.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For standpipe and sprinkler specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing fire-suppression systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
    a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

C. NFPA Standards: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the following:
1. NFPA 13, "Installation of Sprinkler Systems."
2. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."

1.8 COORDINATION

A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Sprinkler Cabinets: Finished, wall-mounting, steel cabinet with hinged cover, with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler on Project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell end and plain end.
1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern.
2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron gland, rubber gasket, and steel bolts and nuts.

B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell end and plain end.
1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern
2. Gaskets: AWWA C111, rubber.

C. Grooved-End, Ductile-Iron Pipe: AWWA C151, with factory- or field-formed, radius-cut-grooved ends according to AWWA C606.
1. Grooved-Joint Piping Systems:
    a. [Available]Manufacturers:
        1) Victaulic Co. of America.
        2) anvil
    b. Grooved-End Fittings: ASTM A 536, ductile-iron casting with OD matching ductile-iron-pipe OD and cement lining.
    c. Grooved-End-Pipe Couplings: AWWA C606, gasketed fitting matching ductile-iron-pipe OD. Include ductile-iron housing with keys matching ductile-iron-pipe and fitting grooves, prelubricated rubber gasket with center leg, and steel bolts and nuts.
    d. Grooved-End-Pipe Transition Coupling: UL 213 and AWWA C606, gasketed fitting with end matching ductile-iron-pipe OD and end matching steel-pipe OD. Include ductile-iron housing with

key matching ductile-iron-pipe groove and key matching steel-pipe groove, prelubricated rubber gasket listed for use with housing, and steel bolts and nuts.

e. Grooved-End Transition Flange: UL 213, gasketed fitting with key for ductile-iron-pipe dimensions. Include flange-type, ductile-iron housing with rubber gasket listed for use with housing and steel bolts and nuts.

2.3 STEEL PIPE AND FITTINGS

A. Threaded-End, Standard-Weight Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795, hot-dip galvanized where indicated and with factory- or field-formed threaded ends.
1. Cast-Iron Threaded Flanges: ASME B16.1.
2. Malleable-Iron Threaded Fittings: ASME B16.3.
3. Gray-Iron Threaded Fittings: ASME B16.4.
4. Steel Threaded Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, seamless steel pipe hot-dip galvanized where indicated. Include ends matching joining method.
5. Steel Threaded Couplings: ASTM A 865, hot-dip galvanized-steel pipe where indicated.

B. Plain-End, Standard-Weight Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795[hot-dip galvanized-steel pipe where indicated].
1. Locking-Lug Fittings: UL 213, ductile-iron body with retainer lugs that require one-quarter turn to secure pipe in fitting.
a. Manufacturers:
1) Anvil International, Inc.
2) Victaulic Co. of America.
3) Ward Manufacturing.

C. Plain-End, Standard-Weight Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795, hot-dip galvanized-steel pipe where indicated.
1. Steel Welding Fittings: ASTM A 234/A 234M, and ASME B16.9 or ASME B16.11.
2. Steel Flanges and Flanged Fittings: ASME B16.5.

D. Grooved-End, Standard-Weight Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795, hot-dip galvanized where indicated and with factory- or field-formed, roll-grooved ends.
1. Grooved-Joint Piping Systems:
a. Manufacturers:
1) Anvil International, Inc.
2) Central Sprinkler Corp.
3) Ductilic, Inc.
4) JDH Pacific, Inc.
5) National Fittings, Inc.
6) Shurjoint Piping Products, Inc.
7) Southwestern Pipe, Inc.
8) Star Pipe Products; Star Fittings Div.
9) Victaulic Co. of America.
10) Ward Manufacturing.
b. Grooved-End Fittings: UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD.
c. Grooved-End-Pipe Couplings: UL 213 and AWWA C606, rigid pattern, unless otherwise indicated; gasketed fitting matching steel-pipe OD. Include ductile-iron housing with keys matching steel-pipe and fitting grooves, prelubricated rubber gasket listed for use with housing, and steel bolts and nuts.
d. Grooved-End Fittings: UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD.
e. Grooved-End-Pipe Couplings: UL 213 and AWWA C606, rigid pattern, unless otherwise indicated; gasketed fitting matching steel-pipe OD. Include ductile-iron housing with keys matching steel-pipe and fitting grooves, prelubricated rubber gasket listed for use with housing, and steel bolts and nuts.

2.4 COPPER TUBE AND FITTINGS

A. Soft Copper Tube: ASTM B 88, Type L, water tube, annealed temper; with plain ends.
   1. Copper fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.
   2. Brazing Filler Metals: AWS A5.8, BCuP-3 or BCuP-4.

B. Plain-End, Hard Copper Tube: ASTM B 88, Type L, water tube, drawn temper.
   1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.
   2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match tubing system.
   3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body with ball-and-socket metal-to-metal seating surfaces, and solder-joint or threaded ends.
   4. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
      a. Manufacturers:
         1) T-Drill Industries, Inc.
   5. Brazing Filler Metals: AWS A5.8, BCuP-3 or BCuP-4.

C. Grooved-End, Hard Copper Tube ASTM B 88, Type L, water tube, drawn temper; with factory- or field-formed, roll-grooved ends.

   1. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
      a. Available Manufacturers:
         1) T-Drill Industries, Inc.
   2. Grooved-Joint Systems:
      a. Available Manufacturers:
      b. Anvil International, Inc.
         1) Victaulic Co. of America.
      c. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting. Fittings may have ends factory or field expanded to steel-pipe OD if required for copper tube systems using grooved-end-pipe couplings.
      d. Grooved-End-Tube Couplings: UL 213, rigid pattern, unless otherwise indicated; gasketed fitting equivalent to AWWA C606, but made to match copper-tube OD. Include ductile-iron housing with keys matching steel-pipe and fitting grooves, prelubricated rubber gasket listed for use with housing, and steel bolts and nuts. Use grooved-end-pipe couplings for tube and fitting that have expanded ends.

2.5 DIELECTRIC FITTINGS

A. Assembly shall be copper alloy, ferrous, and insulating materials with ends matching piping system.

B. Dielectric Unions: Factory-fabricated assembly, designed for 250-psig minimum working pressure at 180 deg F. Include insulating material that isolates dissimilar materials and ends with inside threads according to ASME B1.20.1.
   1. Manufacturers:
      a. Capitol Manufacturing Co.
      b. Central Plastics Company.
      c. Epco Sales, Inc.
      d. Hart Industries International, Inc.
      e. Watts Industries, Inc.; Water Products Div.
      f. Zurn Industries, Inc.; Wilkins Div.

C. Dielectric Flanges: Factory-fabricated companion-flange assembly, for 175-psig minimum working-pressure rating as required for piping system.
   1. Manufacturers:
      a. Capitol Manufacturing Co.
      b. Central Plastics Company.
      c. Epco Sales, Inc.
      d. Watts Industries, Inc.; Water Products Div.

D. Dielectric Flange Insulation Kits: Components for field assembly shall include CR or phenolic gasket, PE or phenolic bolt sleeves, phenolic washers, and steel backing washers.
   1. Manufacturers:
      a. Advance Products and Systems, Inc.
      b. Calpico, Inc.
      c. Central Plastics Company.
      d. Pipeline Seal and Insulator, Inc.

E. Dielectric Couplings: Galvanized steel with inert and noncorrosive thermoplastic lining and threaded ends and 300-psig working-pressure rating at 225 deg F.
   1. Manufacturers:
      a. Calpico, Inc.
      b. Lochinvar Corp.

F. Dielectric Nipples: Electroplated steel with inert and noncorrosive thermoplastic lining, with combination of plain, threaded, or grooved ends and 300-psig working-pressure rating at 225 deg F.
   1. Manufacturers:
      a. Perfection Corporation.
      b. Precision Plumbing Products, Inc.
      c. Victaulic Co. of America.

2.6 SPRINKLER SPECIALTY FITTINGS

A. Sprinkler specialty fittings shall be UL listed or FMG approved, with 175-psig minimum working-pressure rating, and made of materials compatible with piping. Sprinkler specialty fittings shall have 250-psig minimum working-pressure rating if fittings are components of high-pressure piping system.

B. Outlet Specialty Fittings:
   1. Manufacturers:
      a. Anvil International, Inc.
      b. Central Sprinkler Corp.
      c. Ductilic, Inc.
      d. JDH Pacific, Inc.
      e. National Fittings, Inc.
      f. Shurjoint Piping Products, Inc.
      g. Southwestern Pipe, Inc.
      h. Star Pipe Products; Star Fittings Div.
      i. Victaulic Co. of America.
      j. Ward Manufacturing.
   2. Mechanical-T and -Cross Fittings: UL 213, ductile-iron housing with gaskets, bolts and nuts, and threaded, locking-lug, or grooved outlets.
   3. Snap-On and Strapless Outlet Fittings: UL 213, ductile-iron housing or casting with gasket and threaded outlet.

C. Sprinkler Drain and Alarm Test Fittings: Cast- or ductile-iron body; with threaded or locking-lug inlet and outlet, test valve, and orifice and sight glass.
   1. Manufacturers:
      a. Central Sprinkler Corp.
      b. Fire-End and Croker Corp.
      c. Viking Corp.
      d. Victaulic Co. of America.

D. Sprinkler Branch-Line Test Fittings: Brass body with threaded inlet, capped drain outlet, and threaded outlet for sprinkler.
   1. Manufacturers:
      a. Elkhart Brass Mfg. Co., Inc.
      b. Fire-End and Croker Corp.
      c. Potter-Roemer; Fire-Protection Div.

E. Sprinkler Inspector's Test Fitting: Cast- or ductile-iron housing with threaded inlet and drain outlet and sight glass.
   1. Manufacturers:
      a. AGF Manufacturing Co.
      b. Central Sprinkler Corp.
      c. G/J Innovations, Inc.
      d. Triple R Specialty of Ajax, Inc.

F. Drop-Nipple Fittings: UL 1474, adjustable with threaded inlet and outlet, and seals.
   1. Manufacturers:
      a. CECA, LLC.
      b. Merit.

G. Dry-Pipe-System Fittings: UL listed for dry-pipe service.

2.7 LISTED FIRE-PROTECTION VALVES

A. Valves shall be UL listed or FMG approved, with 175-psig minimum pressure rating. Valves shall have 250-psig minimum pressure rating if valves are components of high-pressure piping system.

B. Gate Valves with Wall Indicator Posts:
   1. Gate Valves: UL 262, cast-iron body, bronze mounted, with solid disc, nonrising stem, operating nut, and flanged ends.

C. Ball Valves: Comply with UL 1091, except with ball instead of disc.
   1. NPS 1-1/2 and Smaller: Bronze body with threaded ends.
   2. NPS 2 and NPS 2-1/2: Bronze body with threaded ends or ductile-iron body with grooved ends.
   3. NPS 3: Ductile-iron body with grooved ends.
   4. Available Manufacturers:
      a. NIBCO.
      b. Victaulic Co. of America.

D. Butterfly Valves: UL 1091.
   1. NPS 2 and Smaller: Bronze body with threaded ends.
      a. Available Manufacturers:
         1) Global Safety Products, Inc.
         2) Milwaukee Valve Company.

   2. NPS 2-1/2 and Larger: Bronze, cast-iron, or ductile-iron body; wafer type or with flanged or grooved ends.
      a. Manufacturers:
         1) Central Sprinkler Corp.
         2) Global Safety Products, Inc.
         3) McWane, Inc.; Kennedy Valve Div.
         4) Mueller Company.
         5) NIBCO.
         6) Pratt, Henry Company.
         7) Victaulic Co. of America.

E. Check Valves NPS 2 and Larger: UL 312, swing type, cast-iron body with flanged or grooved ends.
   1. Manufacturers:
      a. AFAC Inc.
      b. American Cast Iron Pipe Co.; Waterous Co.
      c. Central Sprinkler Corp.
      d. Clow Valve Co.
      e. Crane Co.; Crane Valve Group; Crane Valves.
      f. Crane Co.; Crane Valve Group; Jenkins Valves.
      g. Firematic Sprinkler Devices, Inc.
      h. Globe Fire Sprinkler Corporation.
      i. Grinnell Fire Protection.
      j. Hammond Valve.

k. Matco-Norca, Inc.
l. McWane, Inc.; Kennedy Valve Div.
m. Mueller Company.
n. NIBCO.
o. Potter-Roemer; Fire Protection Div.
p. Reliable Automatic Sprinkler Co., Inc.
q. Star Sprinkler Inc.
r. Stockham.
s. United Brass Works, Inc.
t. Venus Fire Protection, Ltd.
u. Victaulic Co. of America.
v. Watts Industries, Inc.; Water Products Div.

F. Gate Valves: UL 262, OS and Y type.
1. NPS 2 and Smaller: Bronze body with threaded ends.
a. Manufacturers:
1) Crane Co.; Crane Valve Group; Crane Valves.
2) Hammond Valve.
3) NIBCO.
4) United Brass Works, Inc.
2. NPS 2-1/2 and Larger: Cast-iron body with flanged ends.
a. Manufacturers:
1) Clow Valve Co.
2) Crane Co.; Crane Valve Group; Crane Valves.
3) Crane Co.; Crane Valve Group; Jenkins Valves.
4) Hammond Valve.
5) Milwaukee Valve Company.
6) Mueller Company.
7) NIBCO.
8) Red-White Valve Corp.
9) United Brass Works, Inc.

G. Indicating Valves: UL 1091, with integral indicating device and ends matching connecting piping.
1. Indicator: [Electrical, 115-V ac, prewired, single-circuit, supervisory switch] [Electrical, 115-V ac, prewired, 2-circuit, supervisory switch] [Visual].
2. NPS 2 and Smaller: Ball or butterfly valve with bronze body and threaded ends.
a. Manufacturers:
1) Milwaukee Valve Company.
2) NIBCO.
3) Victaulic Co. of America.
3. NPS 2-1/2 and Larger: Butterfly valve with cast- or ductile-iron body; wafer type or with flanged or grooved ends.
a. Manufacturers:
1) Central Sprinkler Corp.
2) Grinnell Fire Protection.
3) McWane, Inc.; Kennedy Valve Div.
4) Milwaukee Valve Company.
5) NIBCO.
6) Victaulic Co. of America.

2.8 UNLISTED GENERAL-DUTY VALVES

A. Ball Valves NPS 2 and Smaller: MSS SP-110, 2-piece copper-alloy body with chrome-plated brass ball, 600-psig minimum CWP rating, blowout-proof stem, and threaded ends.

B. Check Valves NPS 2 and Smaller: MSS SP-80, Type 4, Class 125 minimum, swing type with bronze body, nonmetallic disc, and threaded ends.

C. Gate Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, solid wedge, and threaded ends.

2.9 SPECIALTY VALVES

A. Sprinkler System Control Valves: UL listed or FMG approved, cast- or ductile-iron body with flanged or grooved ends, and 175-psig minimum pressure rating. Control valves shall have 250-psig minimum pressure rating if valves are components of high-pressure piping system.
   1. Manufacturers:
      a. AFAC Inc.
      b. Central Sprinkler Corp.
      c. Firematic Sprinkler Devices, Inc.
      d. Globe Fire Sprinkler Corporation.
      e. Grinnell Fire Protection.
      f. Reliable Automatic Sprinkler Co., Inc.
      g. Star Sprinkler Inc.
      h. Venus Fire Protection, Ltd.
      i. Victaulic Co. of America.
      j. Viking Corp.
   2. Alarm Check Valves: UL 193, designed for horizontal or vertical installation, with bronze grooved seat with O-ring seals, single-hinge pin, and latch design. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.
      a. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
      b. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

   3. Dry-Pipe Valves: UL 260, differential type; with bronze seat with O-ring seals, single-hinge pin, and latch design. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
      a. Air-Pressure Maintenance Device: UL 260, automatic device to maintain correct air pressure in piping. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig adjustable range, and 175-psig maximum inlet pressure.
         1) Available Manufacturers:
            a) AFAC Inc.
            b) Central Sprinkler Corp.
            c) General Air Products, Inc.
            d) Globe Fire Sprinkler Corporation.
            e) Grinnell Fire Protection.
            f) Reliable Automatic Sprinkler Co., Inc.
            g) Star Sprinkler Inc.
            h) Viking Corp.
      b. Air Compressor: UL 753, fractional horsepower, 120-V ac, 60 Hz, single phase.
         1) Manufacturers:
            a) AFAC Inc.
            b) Gast Manufacturing, Inc.
            c) Grinnell Fire Protection.
            d) Reliable Automatic Sprinkler Co., Inc.
            e) Viking Corp.

B. Automatic Drain Valves: UL 1726, NPS 3/4, ball-check device with threaded ends.
   1. Manufacturers:
      a. AFAC Inc.
      b. Grinnell Fire Protection.

2.10 MANUAL CONTROL STATIONS

A. Manual Control Stations: UL listed or FMG approved, hydraulic operation, with union, NPS 1/2 pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

2.11 SPRINKLERS

A. Sprinklers shall be UL listed or FMG approved, with 175-psig minimum pressure rating. Sprinklers shall have 250-psig minimum pressure rating if sprinklers are components of high-pressure piping system.

B. Manufacturers:
1. AFAC Inc.
2. Central Sprinkler Corp.
3. Firematic Sprinkler Devices, Inc.
4. Globe Fire Sprinkler Corporation.
5. Grinnell Fire Protection.
6. Reliable Automatic Sprinkler Co., Inc.
7. Star Sprinkler Inc.
8. Venus Fire Protection, Ltd.
9. Victaulic Co. of America.
10. Viking Corp.

C. Sprinkler Types and Categories: Nominal 1/2-inch orifice for "Ordinary" temperature classification rating, unless otherwise indicated or required by application.
1. Open Sprinklers: UL 199, without heat-responsive element.
a. Orifice: 1/2 inch, with discharge coefficient K between 5.3 and 5.8.

D. Sprinkler types, features, and options as follows:
1. Concealed ceiling sprinklers, including cover plate.
2. Extended-coverage sprinklers.
3. Flush ceiling sprinklers, including escutcheon.
4. Pendent sprinklers.
5. Pendent, dry-type sprinklers.
6. Quick-response sprinklers.
7. Recessed sprinklers, including escutcheon.
8. Sidewall sprinklers.
9. Sidewall, dry-type sprinklers.
10. Upright sprinklers.

E. Sprinkler Finishes: Chrome plated, bronze, and painted.

F. Special Coatings: Wax, lead, and corrosion-resistant paint.

G. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
1. Ceiling Mounting: Chrome-plated steel, 2 piece, with 1-inch vertical adjustment
2. Sidewall Mounting: Chrome-plated steel one piece, flat.

H. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler.

2.12 HOSE CONNECTIONS

A. Manufacturers:
1. AFAC Inc.
2. Central Sprinkler Corp.
3. Elkhart Brass Mfg. Co., Inc.
4. Fire-End and Croker Corp.
5. Fire Protection Products, Inc.
6. GMR International Equipment Corporation.
7. Grinnell Fire Protection.
8. Guardian Fire Equipment Incorporated.
9. McWane, Inc.; Kennedy Valve Div.
10. Mueller Company.
11. Potter-Roemer; Fire-Protection Div.
12. United Brass Works, Inc.

B. Description: UL 668, brass or bronze, 300-psig minimum pressure rating, hose valve for connecting fire hose. Include angle or gate pattern design; female NPS inlet and male hose outlet; and lugged cap,

gasket, and chain. Include NPS 1-1/2 or NPS 2-1/2 as indicated, and hose valve threads according to NFPA 1963 and matching local fire department threads.

1. Valve Operation: Nonadjustable.
2. Finish: Rough chrome-plated.

2.13 FIRE DEPARTMENT CONNECTIONS

A. Manufacturers:
   1. AFAC Inc.
   2. Central Sprinkler Corp.
   3. Elkhart Brass Mfg. Co., Inc.
   4. Fire-End and Croker Corp.
   5. Fire Protection Products, Inc.
   6. GMR International Equipment Corporation.
   7. Guardian Fire Equipment Incorporated.
   8. Potter-Roemer; Fire-Protection Div.
   9. Reliable Automatic Sprinkler Co., Inc.
   10. United Brass Works, Inc.

B. Wall-Type, “STORZ” with 30° angle, Fire Department Connection: UL 405, 175-psig minimum pressure rating; with corrosion-resistant-metal body with brass inlets, brass wall escutcheon plate, brass lugged caps with gaskets and brass chains, and brass lugged swivel connections. Include inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, outlet with pipe threads, extension pipe nipples, check devices or clappers for inlets, and escutcheon plate with marking similar to "AUTO SPKR and STANDPIPE."
   1. Type: Exposed, STORZ” with 30° angle and square or rectangular escutcheon plate.
   2. Finish: Polished chrome-plated.

2.14 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Water-Motor-Operated Alarm: UL 753, mechanical-operation type with pelton-wheel operator with shaft length, bearings, and sleeve to suit wall construction and 10-inch- diameter, cast-aluminum alarm gong with red-enamel factory finish. Include NPS 3/4 inlet and NPS 1 drain connections.
   1. Manufacturers:
      a. AFAC Inc.
      b. Central Sprinkler Corp.
      c. Firematic Sprinkler Devices, Inc.
      d. Globe Fire Sprinkler Corporation.
      e. Grinnell Fire Protection.
      f. Reliable Automatic Sprinkler Co., Inc.
      g. Star Sprinkler Inc.
      h. Viking Corp.

C. Electrically Operated Alarm: UL 464, with 10-inch diameter, vibrating-type, metal alarm bell with red-enamel factory finish and suitable for outdoor use.
   1. Manufacturers:
      a. Potter Electric Signal Company.
      b. System Sensor.

D. Water-Flow Indicator: UL 346, electrical-supervision, paddle-operated-type, water-flow detector with 250-psig pressure rating and designed for horizontal or vertical installation. Include two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
   1. Manufacturers:
      a. ADT Security Services, Inc.
      b. Grinnell Fire Protection.
      c. ITT McDonnell and Miller.
      d. Potter Electric Signal Company.
      e. System Sensor.

f. Viking Corp.
g. Watts Industries, Inc.; Water Products Div.

E. Pressure Switch: UL 753, electrical-supervision-type, water-flow switch with retard feature. Include single-pole, double-throw, normally closed contacts and design that operates on rising pressure and signals water flow.
1. Manufacturers:
a. Grinnell Fire Protection.
b. Potter Electric Signal Company.
c. System Sensor.
d. Viking Corp.

F. Valve Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled valve is in other than fully open position.
1. Available Manufacturers:
a. McWane, Inc.; Kennedy Valve Div.
b. Potter Electric Signal Company.
c. System Sensor.

G. Indicator-Post Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled indicator-post valve is in other than fully open position.
1. Manufacturers:
a. Potter Electric Signal Company.
b. System Sensor.

2.15 PRESSURE GAGES

A. Manufacturers:
1. AGF Manufacturing Co.
2. AMETEK, Inc.; U.S. Gauge.
3. Brecco Corporation.
4. Dresser Equipment Group; Instrument Div.
5. Marsh Bellofram.
6. WIKA Instrument Corporation.

B. Description: UL 393, 3-1/2- to 4-1/2-inch- diameter, dial pressure gage with range of 0 to 250 psig minimum.
1. Water System Piping: Include caption "WATER" or "AIR/WATER" on dial face.
2. Air System Piping: Include retard feature and caption "AIR" or "AIR/WATER" on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13, NFPA 14, and NFPA 291. Use results for system design calculations required in Part 1 "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.2 EARTHWORK

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.3 EXAMINATION

A. Examine roughing-in for hose connections and stations to verify actual locations of piping connections before installation.

B. Examine walls and partitions for suitable thicknesses, fire- and smoke-rated construction, framing for hose-station cabinets, and other conditions where hose connections and stations are to be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 PIPING APPLICATIONS, GENERAL

A. Shop weld pipe joints where welded piping is indicated.

B. Do not use welded joints for galvanized-steel pipe.

C. Flanges, flanged fittings, unions, nipples, and transition and special fittings with finish and pressure ratings same as or higher than system's pressure rating may be used in aboveground applications, unless otherwise indicated.

D. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with grooved ends grooved-end fittings and grooved joints.

E. Underground Service-Entrance Piping: Ductile-iron, mechanical-joint pipe and fittings and restrained joints. Include corrosion-protective encasement.

F. Underground Service-Entrance Piping: Ductile-iron, grooved-end pipe and fittings; grooved-end-pipe couplings; and grooved joints. Include corrosion-protective encasement.]

G. Underground Service-Entrance Piping: Type L, soft copper tube; wrought-copper fittings; and brazed joints. Include corrosion-protective encasement.

3.5 STANDPIPE SYSTEM PIPING APPLICATIONS

A. Standard-Pressure, Wet-Type Standpipe System, 175-psig Maximum Working Pressure:
1. Threaded-end, black or galvanized standard-weight steel pipe; cast- or malleable-iron threaded fittings; and threaded joints, or rolled groove joints.

3.6 VALVE APPLICATIONS

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
1. Listed Fire-Protection Valves: UL listed and FMG approved for applications where required by NFPA 13 and NFPA 14.
a. Shutoff Duty: Use ball, butterfly, or gate valves.
2. Unlisted General-Duty Valves: For applications where UL-listed and FMG-approved valves are not required by NFPA 13 and NFPA 14.
a. Shutoff Duty: Use ball, butterfly, or gate valves.
b. Throttling Duty: Use ball or globe valves.

3.7 JOINT CONSTRUCTION

A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic piping joint construction.

B. Threaded Joints: Comply with NFPA 13 for pipe thickness and threads. Do not thread pipe smaller than NPS 8 (DN 200) with wall thickness less than Schedule 40 unless approved by authorities having jurisdiction and threads are checked by a ring gage and comply with ASME B1.20.1.

C. Pressure-Sealed Joints: Use UL-listed tool and procedure. Include use of specific equipment, pressure-sealing tool, and accessories.

D. Mechanically Formed, Copper-Tube-Outlet Joints: Use UL-listed tool and procedure. Drill pilot hole in copper tube, form branch for collar, dimple tube to form seating stop, and braze branch tube into formed-collar outlet.

E. Grooved Joints: Assemble joints with listed coupling and gasket, lubricant, and bolts.
1. Ductile-Iron Pipe: Radius-cut-groove ends of piping. Use grooved-end fittings and grooved-end-pipe couplings.
2. Steel Pipe: Square-cut or roll-groove piping as indicated. Use grooved-end fittings and rigid, grooved-end-pipe couplings, unless otherwise indicated.
3. Copper Tube: Roll-groove tubing. Use grooved-end fittings and grooved-end-tube couplings.
4. Dry-Pipe Systems: Use fittings and gaskets listed for dry-pipe service.

F. Dissimilar-Metal Piping Joints: Construct joints using dielectric fittings compatible with both piping materials.
1. NPS 2 and Smaller: Use dielectric unions, couplings, or nipples.
2. NPS 2-1/2 to NPS 4: Use dielectric flanges.
3. NPS 5 and Larger: Use dielectric flange insulation kits.

3.8 SERVICE-ENTRANCE PIPING

A. Connect fire-suppression piping to water-service piping of size and in location indicated for service entrance to building. Refer to Division 22 Section "Facility Water Distribution Piping" for exterior piping.

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping. Refer to Division 22 Section "Facility Water Distribution Piping" for backflow preventers.

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.9 WATER-SUPPLY CONNECTION

A. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water distribution piping. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers.

3.10 PIPING INSTALLATION

A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic piping installation.

B. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
   1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

C. Install underground ductile-iron service-entrance piping according to NFPA 24 and with restrained joints Encase piping in corrosion-protective encasement.

D. Install underground copper service-entrance piping according to NFPA 24.Encase piping in corrosion-protective encasement.

E. Use approved fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

F. Install unions adjacent to each valve in pipes NPS 2 and smaller. Unions are not required on flanged devices or in piping installations using grooved joints.

G. Install flanges or flange adapters on valves, apparatus, and equipment having NPS 2-1/2 and larger connections.

H. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13.

I. Install sprinkler piping with drains for complete system drainage.

J. Install sprinkler zone control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

K. Install drain valves on standpipes.

L. Install ball drip valves to drain piping between fire department connections and check valves. Drain to floor drain or outside building.

M. Install alarm devices in piping systems.

N. Hangers and Supports: Comply with NFPA 13 for hanger materials.
   1. Install standpipe system piping according to NFPA 14.
   2. Install sprinkler system piping according to NFPA 13.

O. Earthquake Protection: Install piping according to NFPA 13 to protect from earthquake damage.

P. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

Q. Drain dry-type standpipe piping.

R. Drain dry-pipe sprinkler piping.

S. Pressurize and check dry-pipe sprinkler system piping and air-pressure maintenance devices, air compressors.

T. Fill wet-standpipe system piping with water.

U. Fill wet-pipe sprinkler system piping with water.

V. Install flexible connectors in fire-suppression piping where indicated.

3.11 VALVE INSTALLATION

A. Install listed fire-protection valves, unlisted general-duty valves, specialty valves and trim, controls, and specialties according to NFPA 13 and NFPA 14 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water supply sources.

D. Specialty Valves:

1. Alarm Check Valves: Install in vertical position for proper direction of flow, including bypass check valve and retarding chamber drain-line connection.
2. Dry-Pipe Valves: Install trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
    a. Air-Pressure Maintenance Devices for Dry-Pipe Systems: Install shutoff valves to permit servicing without shutting down sprinkler system; bypass valve for quick system filling; pressure regulator or switch to maintain system pressure; strainer; pressure ratings with 14- to 60-psig adjustable range; and 175-psig maximum inlet pressure.
    b. Install air compressor and compressed-air supply piping.
    c. Install compressed-air supply piping from building's compressed-air piping system.

3.12 SPRINKLER APPLICATIONS

A. Drawings indicate sprinkler types to be used. Where specific types are not indicated, use the following sprinkler types:
1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Pendent, recessed, flush, and concealed sprinklers, as indicated.
3. Wall Mounting: Sidewall sprinklers.
4. Spaces Subject to Freezing: Pendent, dry sprinklers, Sidewall, dry sprinklers.
5. Special Applications: Extended-coverage and quick-response sprinklers where indicated.
6. Sprinkler Finishes:
7. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.
    a. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
    b. Flush Sprinklers: Bright chrome, with painted white escutcheon.
    c. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.

3.13 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels and tiles.

B. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing. Use dry-type sprinklers with water supply from heated space.

3.14 HOSE-CONNECTION INSTALLATION

A. Install NPS 2-1/2 hose connections with quick-disconnect NPS 2-1/2 unless otherwise indicated.

B. Install wall-mounting-type hose connections in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Refer to Division 10 Section "Fire Extinguisher Cabinets" for cabinets.

3.15 MONITOR INSTALLATION

A. Install monitor bases securely attached to building substrate.

3.16 FIRE DEPARTMENT CONNECTION INSTALLATION

A. Install wall-type, “STORZ” with 30° angle type fire department connections in vertical wall.

B. Install ball drip valve at each check valve for fire department connection.

3.17 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Connect water-supply piping to fire-suppression piping. Include backflow preventer between potable-water piping and fire-suppression piping. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers.

D. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.

E. Connect piping to specialty valves, hose valves, specialties, fire department connections, and accessories.

F. Connect excess-pressure pumps to the following piping and wiring:
1. Sprinkler system, hydraulically.
2. Pressure gages and controls, hydraulically.
3. Electrical power system.
4. Alarm device accessories for pump.
5. Fire alarm.

G. Connect compressed-air supply to dry-pipe sprinkler piping.

H. Connect air compressor to the following piping and wiring:
1. Pressure gages and controls.
2. Electrical power system.
3. Fire alarm devices, including low-pressure alarm.

I. Electrical Connections: Power wiring is specified in Division 26.

J. Connect alarm devices to fire alarm.

K. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

M. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.18 LABELING AND IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and NFPA 14.

3.19 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Energize circuits to electrical equipment and devices.
4. Start and run excess-pressure pumps.
5. Start and run air compressors.
6. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
7. Coordinate with fire alarm tests. Operate as required.
8. Coordinate with fire-pump tests. Operate as required.
9. Verify that equipment hose threads are same as local fire department equipment.

B. Report test results promptly and in writing to Architect and authorities having jurisdiction.

3.20 CLEANING AND PROTECTION

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

C. Protect sprinklers from damage until Substantial Completion.

3.21 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
8. Plumbing demolition.
9. Equipment installation requirements common to equipment sections.
10. Painting and finishing.
11. Concrete bases.
12. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:
1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. CPVC: Chlorinated polyvinyl chloride plastic.
3. PE: Polyethylene plastic.
4. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:
1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:
1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

1.5 QUALITY ASSURANCE

A. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

B. Performance criteria for specified equipment and materials shall take precedence over selected model numbers.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

2.4 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
1. Manufacturers:
a. Cascade Waterworks Mfg. Co.
b. Dresser Industries, Inc.; DMD Div.
c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
d. JCM Industries.
e. Smith-Blair, Inc.
f. Viking Johnson.
2. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.

3. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.
4. Aboveground Pressure Piping: Pipe fitting.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
1. Manufacturers:
a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Eclipse, Inc.
d. Epco Sales, Inc.
e. Hart Industries, International, Inc.
f. Watts Industries, Inc.; Water Products Div.
g. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
1. Manufacturers:
a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.
d. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
1. Manufacturers:
a. Advance Products and Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.
2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
1. Manufacturers:
a. Calpico, Inc.
b. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.
1. Manufacturers:
a. Sioux Chief Manufacturing Co., Inc.
b. Victaulic Co. of America.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
1. Manufacturers:
a. Advance Products and Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.
2. Sealing Elements: Compatible interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

3. Pressure Plates: Stainless steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
1. Underdeck Clamp: Clamping ring with set screws.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.
1. Finish: Polished chrome-plated Rough brass Polished chrome-plated and rough brass.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
1. Finish: Polished chrome-plated Rough brass Polished chrome-plated and rough brass.

E. One-Piece, Floor-Plate Type: Cast-iron floor plate.

F. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PLUMBING DEMOLITION

A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and equipment and make other design decisions. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
   1. New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, cast-brass, chrome plated deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
      c. Insulated Piping: One-piece, cast brass type with spring clips.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast-brass type with polished chrome-plated finish.
      e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
      f. Bare Piping in Unfinished Service Spaces and Equipment Rooms: Split casting, cast-brass type with polished chrome-plated finish.
      g. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
   2. Existing Piping: Use the following:
      a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
      b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge and spring clips.
      c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
      d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
      e. Bare Piping in Unfinished Service Spaces and equipment rooms: Split-casting, cast-brass type with polished chrome-plated finish.
      f. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas, plumbing wet-walls or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping rings.
   2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
   3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
      a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
      b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
      c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
1. Install unions, in piping NPS 3 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping 4” and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.6 PAINTING

A. Painting of plumbing systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.9 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.10 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors.

B. Escutcheons for New Piping:
1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.

2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated.
3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish
4. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated.
5. Bare Piping in Equipment Rooms: One piece, cast brass.
6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

C. Escutcheons for Existing Piping:
1. Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
2. Insulated Piping: Split plate, stamped steel with concealed exposed-rivet concealed hinge and spring clips.
3. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish plate.
4. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish plate.
5. Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish casting, and set screw.
6. Bare Piping in Equipment Rooms: Split casting, cast brass plate, with set screw.
7. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

3.11 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION

COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   1. Motor controllers.
   2. Torque, speed, and horsepower requirements of the load.
   3. Ratings and characteristics of supply circuit and required control sequence.
   4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
   2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F or better.

J. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Energy- Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
   1. Permanent-split capacitor.
   2. Split phase.
   3. Capacitor start, inductor run.
   4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (NOT APPLICABLE)

END OF SECTION

EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Metal-bellows expansion joints.
2. Rubber expansion joints.
3. Flexible-hose expansion joints.
4. Pipe bends and loops.
5. Alignment guides and anchors.

1.3 DEFINITIONS

A. BR: Butyl rubber.

B. Buna-N: Nitrile rubber.

C. CR: Chlorosulfonated polyethylene synthetic rubber.

D. CSM: Chlorosulfonyl-polyethylene rubber.

E. EPDM: Ethylene-propylene-diene terpolymer rubber.

F. NR: Natural rubber.

1.4 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping system fluids, materials, working pressures, and temperatures.

B. Capability: Products shall absorb 200 percent of maximum axial movement between anchors.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Delegated-Design Submittal (where called for): For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and bends.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

C. Welding certificates.

D. Product Certificates: For each type of pipe expansion joint, signed by product manufacturer.

E. Maintenance Data: For pipe expansion joints to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:
1. Steel Shapes and Plates: AWS D1.1, "Structural Welding Code - Steel."
2. Welding to Piping: ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 EXPANSION JOINTS

A. Metal-Bellows Expansion Joints: ASTM F 1120, circular-corrugated-bellows type with external tie rods.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Adsco Manufacturing, LLC.

b. Anamet, Inc.
c. Badger Industries.
d. Expansion Joint Systems, Inc.
e. Flex-Hose Co., Inc.
f. Flexicraft Industries.
g. Flex-Pression, Ltd.
h. Flex-Weld, Inc.
i. Hyspan Precision Products, Inc.
j. Metraflex, Inc.
k. Piping Technology and Products, Inc.
l. Proco Products, Inc.
m. Senior Flexonics, Inc.; Pathway Division.
n. Tozen America Corp.
o. Unaflex Inc.
p. WahlcoMetroflex.

2. Metal-Bellows Expansion Joints for Copper Piping: Single- or multiple Multiple-ply phosphor-bronze bellows, copper pipe end connections, and brass shrouds.
3. Metal-Bellows Expansion Joints for Steel Piping: Single- or multiple Multiple-ply stainless-steel bellows, steel pipe end connections, and carbon-steel shroud.
4. Minimum Pressure Rating: 175 psig, unless otherwise indicated.
5. Configuration: Single- or double Double-bellows type with base, unless otherwise indicated.
6. End Connections: Flanged or welded.

B. Rubber Expansion Joints: ASTM F 1123, fabric-reinforced rubber with external control rods and complying with FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Flex-Hose Co., Inc.
b. Flexicraft Industries.
c. Flex-Weld, Inc.
d. Garlock Sealing Technologies.
e. General Rubber Corp.
f. Mason Industries, Inc.; Mercer Rubber Co.
g. Metraflex, Inc.
h. MG Piping Products Co.
i. Proco Products, Inc.
j. Red Valve Company, Inc.
k. Senior Flexonics, Inc.; Pathway Division.
l. Tozen America Corp.
m. Unaflex Inc.
n. Vibration Mountings and Controls, Inc.
o. Arch Type: Single or multiple Multiple arches.
2. Spherical Type: Single or multiple Multiple spheres.
a. Minimum Pressure and Temperature Ratings for NPS 1-1/2 to NPS 4: 150 psig at 220 deg F
b. Minimum Pressure and Temperature Ratings for NPS 5 and NPS 6: 140 psig at 200 deg F
c. Minimum Pressure and Temperature Ratings for NPS 8 to NPS 12: 140 psig at 180 deg F
3. Material: BR Buna-N CR CSM EPDM NR.
4. End Connections: Full-faced, integral, steel flanges with steel retaining rings.

C. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Flex-Hose Co., Inc.
b. Flexicraft Industries.
c. Flex-Pression, Ltd.
d. Metraflex, Inc.
2. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder- joint end connections.

a. NPS 2 and Smaller: Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.

3. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder- joint end connections.
   a. NPS 2 and Smaller: Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F and 500 psig at 450 deg F ratings.
   b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F and 315 psig at 450 deg F ratings.
4. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 and smaller and flanged or welded end connections for NPS 2-1/2 and larger.
   a. NPS 2 and Smaller: Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
   b. NPS 2-1/2 to NPS 6: Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.
   c. NPS 8 to NPS 12: Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F and 90 psig at 600 deg F ratings.
5. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 and smaller and flanged or welded end connections for NPS 2-1/2 and larger.
   a. NPS 2 and Smaller: Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F and 515 psig at 600 deg F ratings.
   b. NPS 2-1/2 to NPS 6: Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F and 200 psig at 600 deg F ratings.
   c. NPS 8 and Larger: Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.

2.2 ALIGNMENT GUIDES

A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Adsco Manufacturing, LLC.
      b. Advanced Thermal Systems, Inc.
      c. Flex-Hose Co., Inc.
      d. Flexicraft Industries.
      e. Flex-Weld, Inc.
      f. Hyspan Precision Products, Inc.
      g. Metraflex, Inc.
      h. Piping Technology and Products, Inc.
      i. Senior Flexonics, Inc.; Pathway Division.

2.3 MATERIALS FOR ANCHORS

A. Steel Shapes and Plates: ASTM A 36/A 36M.

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.
   1. Stud: Threaded, zinc-coated carbon steel.
   2. Expansion Plug: Zinc-coated steel.
   3. Washer and Nut: Zinc-coated steel.

E. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.
   1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
   2. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.

3. Washer and Nut: Zinc-coated steel.

F. Concrete: Portland cement mix, 3000 psi minimum. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.

G. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink, nonmetallic grout; suitable for interior and exterior applications.
1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

A. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

B. Install expansion joints of sizes matching size of piping in which they are installed.

C. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

3.2 PIPE BEND AND LOOP INSTALLATION

A. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Attach pipe bends and loops to anchors.
1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

3.3 SWING CONNECTIONS

A. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

3.4 ALIGNMENT-GUIDE INSTALLATION

A. Install guides on piping adjoining pipe expansion fittings and loops.

B. Attach guides to pipe and secure to building structure.

3.5 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints are indicated.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

END OF SECTION

METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Thermometers.
2. Gages.
3. Test plugs.

B. Related Sections:
1. Division 22 Section "Facility Water Distribution Piping" for domestic and fire-protection water service meters outside the building.
2. Division 22 Section "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.
3. Division 23 Section "Facility Natural-Gas Piping" for gas meters.

1.3 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated; include performance curves.

PART 2 - PRODUCTS

2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Weiss Instruments Inc., 9VU 9” Vari-Angle.
2. Trerice, H. O. Co.
3. Palmer - Wahl Instruments Inc.
4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Case: Die-cast aluminum 9 inches long.

C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.

D. Tube Background: Satin-faced, nonreflective aluminum with black markings.

E. Window: Glass.

F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.2 LIGHT POWERED DIGITAL THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Weiss Instruments Inc., DVU Digital Vari-Angle.
2. Trerice, H. O. Co.
3. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Case: ABS plastic or aluminum.

C. Display: 1/2 inch, or greater, LCD digits.

D. Sensor: Glass passivated thermistor.

E. Lux Rating: 10 Lux (one foot-candle).

F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus 1 percent of reading or one degree.

2.3 THERMOWELLS

A. Manufacturers: Same as manufacturer of thermometer being used.

B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.4 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Ernst Gage Co.
3. KOBOLD Instruments, Inc.
4. Miljoco Corp.
5. Trerice, H. O. Co.
6. Weiss Instruments, Inc.
7. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
1. Case: Dry type, cast aluminum 4-1/2-inch diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Red metal.
7. Window: Glass
8. Ring: Brass or stainless steel
9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

C. Pressure-Gage Fittings:
1. Valves: NPS 1/4 brass or stainless-steel needle type.
2. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.5 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Flow Design, Inc.
2. MG Piping Products Co.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Co.
6. Trerice, H. O. Co.
7. Watts Industries, Inc.; Water Products Div.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F

D. Core Inserts: One or two self-sealing rubber valves.
1. Insert material for water service at 20 to 200 deg F shall be CR.
2. Insert material for water service at minus 30 to plus 275 deg F shall be EPDM.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install thermometers in the inlet and outlet of each domestic, hot-water storage tank, water heater and heat exchanger.

B. Install thermometers at the inlets and outlet of all master thermostatic mixing valves.

C. Install thermometers at suction and discharge of each pump.

D. Provide the following temperature ranges for thermometers:
   1. Domestic Hot Water: 30 to 240 deg F, with 2-degree scale divisions
   2. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions

3.2 GAGE APPLICATIONS

A. Install pressure gages for inlet and outlet of each pressure-reducing valve.

B. Install pressure gages at suction and discharge of each pump.

C. Install pressure gages at inlets and outlet of all master thermostatic mixing valves.

3.3 INSTALLATIONS

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees where thermometers are indicated.

B. Install thermometers and adjust vertical and tilted positions.

C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

D. Install needle-valve and snubber fitting in piping for each pressure gage.

E. Install test plugs in tees in piping.

F. Install permanent indicators on walls or brackets in accessible and readable positions.

G. Install connection fittings for attachment to portable indicators in accessible locations.

H. Install thermometers and gages adjacent to machines and equipment to allow service and maintenance for thermometers, gages, machines, and equipment.

I. Adjust faces of thermometers and gages to proper angle for best visibility.

J. Install insulation to fit tightly and cleanly against the tee stems for fittings and thermowells. Provide sleeve or extension where required for a clean installation.

END OF SECTION

GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Bronze ball valves.
2. Bronze lift check valves.
3. Bronze swing check valves.
4. Iron swing check valves.
5. Iron center guided check valves.
6. Iron gate valves.
7. Balancing Valves.
8. Drain Valves

B. Related Sections:
1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
3. Division 33 water distribution piping Sections for general-duty and specialty valves for site construction piping.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS and Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 SUBMITTALS

A. Product Data: For each type of valve indicated.

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:
1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 for valve materials for potable-water service.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use hand wheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:
1. Handwheel: For valves other than quarter-turn types.
2. Handlever: For quarter-turn valves NPS 6 and smaller.

E. Valves in Insulated Piping: With valve stem extensions and the following features:
1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

F. Valve-End Connections: Match pipe joining method
1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Grooved: With grooves according to AWWA C606.
3. Solder Joint: With sockets according to ASME B16.18.
4. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Beeco.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Hammond Valve.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-110.
b. CWP Rating: 200 psig minimum, match plans for greater pressures.
c. Body Design: Two piece.
d. Body Material: Bronze.
e. Ends: SOLDER
f. Seats: PTFE or TFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel, vented.
i. Port: Full.

2.3 BRONZE LIFT CHECK VALVES

A. Lift Check Valves with Nonmetallic Disc:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Conbraco Industries, Inc.; Apollo Valves.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: psig minimum, match plans for greater pressures.
c. Body Design: Vertical flow.
d. Body Material: ASTM B 61 or ASTM B 62, bronze.
e. Ends: SOLDER
f. Disc: NBR, PTFE, or TFE.

2.4 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Bronze or non-metallic Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.
b. Hammond Valve.
c. Kitz Corporation.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-80
b. CWP Rating: 200 minimum, match plans for greater pressures.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

2.5 IRON SWING CHECK VALVES

A. Iron Swing Check Valves with Metal Seats:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co
b. Hammond Valve.
c. Kitz Corporation.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-71
b. CWP Rating: 200 psig. minimum, match plans for greater pressures.
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Match pipe system
f. Trim: Bronze.

2.6 IRON, CENTER-GUIDED CHECK VALVES

A. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co
b. Hammond Valve.
c. Kitz Corporation.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-125.
b. CWP Rating: 200 psig. minimum, match plans for greater pressures.
c. Body Material: ASTM A 126, gray iron.
d. Style: Compact wafer.
e. Seat: Bronze.

2.7 IRON GATE VALVES

A. OS and Y, Iron Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Beeco.
b. Hammond Valve.
c. Crane Co.
d. Kitz Corporation.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-70
b. CWP Rating: 200 psig minimum, match plans for greater pressures.
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

2.8 BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ITT Industries; Bell and Gossett Div.
b. NIBCO INC.
c. Taco, Inc.
d. Watts Industries, Inc.; Water Products Div.
2. Type: Ball or globe valve with two readout ports and memory setting indicator.
3. Body: bronze.
4. Size: Same as connected piping
5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

2.9 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves
1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

B. Gate-Valve-Type, Hose-End Drain Valves
1. Standard: MSS SP-80 for gate valves.
2. Pressure Rating: Class 125.
3. Size: NPS 3/4.
4. Body: ASTM B 62 bronze.
5. Inlet: NPS 3/4 threaded or solder joint.
6. Outlet: Garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

C. Stop-and-Waste Drain Valves
1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: 200-psig minimum CWP or Class 125.
3. Size: NPS 3/4.

4. Body: Copper alloy or ASTM B 62 bronze.
5. Drain: NPS 1/8 side outlet with cap.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install balancing valves in locations where they can easily be adjusted.

F. Install chainwheels on operators for gate valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

G. Install check valves for proper direction of flow and as follows:
1. Swing Check Valves: In horizontal position with hinge pin level.
2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

B. Set field-adjustable flow set points of balancing valves.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:
1. Shutoff Service:
a. NPS 3 and smaller: Ball valve.
b. NPS 4 and larger: OSandY gate.
2. Throttling Service: Ball.
3. Sewage and sump basin discharge to have swing check valves with optional lever and weight or lever and spring, for quiet operation.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves with the following end connections:
1. NPS 3 and smaller: Match the piping system joining method.
2. NPS 4 and larger: Flanged.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 3 and Smaller: Bronze ball valves

B. Pipe NPS 4 and larger: OSandY gate valves

3.6 SANITARY-WASTE AND STORM-DRAINAGE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze with threaded ends

B. Pipe NPS 3 and larger: Iron with flanged ends.

END OF SECTION

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following hangers and supports for plumbing system piping and equipment:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe stands.
   7. Pipe positioning systems.
   8. Equipment supports.

B. Related Sections include the following:
   1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-suppression piping.
   3. Division 22 Section "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.
   4. Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Thermal-hanger shield inserts.
   3. Powder-actuated fastener systems.
   4. Pipe positioning systems.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Available Manufacturers:
   1. AAA Technology and Specialties Co., Inc.
   2. Anvil
   3. Bergen-Power Pipe Supports.
   4. B-Line Systems, Inc.; a division of Cooper Industries.
   5. Carpenter and Paterson, Inc.
   6. Empire Industries, Inc.
   7. ERICO/Michigan Hanger Co.
   8. Globe Pipe Hanger Products, Inc.
   9. Grinnell Corp.
   10. GS Metals Corp.
   11. National Pipe Hanger Corporation.
   12. PHD Manufacturing, Inc.
   13. PHS Industries, Inc.
   14. Piping Technology and Products, Inc.
   15. Tolco Inc.

C. Galvanized, Metallic Coatings: Pre-galvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Available Manufacturers:
   1. B-Line Systems, Inc.; a division of Cooper Industries.
   2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
   3. GS Metals Corp.
   4. Power-Strut Div.; Tyco International, Ltd.
   5. Thomas and Betts Corporation.
   6. Tolco Inc.
   7. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Manufacturers:
   1. Carpenter and Paterson, Inc.
   2. ERICO/Michigan Hanger Co.
   3. PHS Industries, Inc.
   4. Pipe Shields, Inc.
   5. Rilco Manufacturing Company, Inc.
   6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 552, Type II cellular glass.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis Hangers: Insert and shield shall cover lower 180 degrees of pipe.

G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated stainless steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers:
      a. Anvil.
      b. B-Line Systems, Inc.; a division of Cooper Industries
      c. Empire Industries, Inc.
      d. Hilti, Inc.
      e. ITW Ramset/Red Head.
      f. MKT Fastening, LLC.
      g. Powers Fasteners.

2.7 PIPE STAND FABRICATION

A. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.8 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.9 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   1. Properties: Nonstaining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

B. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

C. Use copper hangers for all piping in contact with copper pipe.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching including glass pipe and painted pipe.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
   2. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24 (DN 15 to DN 600), if little or no insulation is required.
   3. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36 (DN 100 to DN 900), with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
   4. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36 (DN 65 to DN 900), if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.

5. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30 (DN 25 to DN 750), from 2 rods if longitudinal movement caused by expansion and contraction might occur.
6. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20 (DN 65 to DN 500), from single rod if horizontal movement caused by expansion and contraction might occur.
7. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42 (DN 50 to DN 1050), if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
8. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24 (DN 50 to DN 600), if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
9. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30 (DN 50 to DN 750), if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500), if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb (340 kg).
   b. Medium (MSS Type 32): 1500 lb (680 kg).
   c. Heavy (MSS Type 33): 3000 lb (1360 kg).
10. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

K. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

L. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

M. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

N. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

3.2 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:
   1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:
   1. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.
   2. Floor supported pipe supports: Manufactured adjustable pipe stanchions bolted to floor and pipes secured with U-bolts.

G. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Division 22 Section "Plumbing Fixtures" for plumbing fixtures.

H. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

K. Install roller type hangers and supports on straight piping runs of 100 feet or more.

L. Install lateral bracing with pipe hangers and supports to prevent swaying.

M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 3 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

N. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.

P. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating below ambient air temperature.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Insert Material: Length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches max.

3.6 PAINTING

A. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections. Section "High-Performance Coatings" or as follows:
   1. Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

   2. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

PART 1- GENERAL

1.1 SECTION INCLUDES

A. Isolation of vibration induced by Plumbing Systems from spaces for which Noise Criteria have been established in Division 1, including vibration isolators, equipment bases, and flexible connections.

1.2 SUMMARY

A. Mount rotating and reciprocating equipment and piping on vibration isolators as noted in the Contract Documents. Select, install and adjust isolators to prevent the transmission of objectionable vibration and noise to the building structure.

1.3 RELATED WORK

A. Perform vibration isolation work in this Contract, including work described in other Divisions, to meet the product and execution requirements of this Section. Related work includes:

1. Division 1 – General Requirements
2. Division 3 – Concrete
3. Division 4 – Masonry
4. Division 5 – Metals
5. Division 14 – Conveying Equipment
6. Division 22 – Plumbing
7. Division 23 – Heating, Ventilating and Air Condition
8. Division 26 – Electrical
9. Section 018601 – General Acoustic Requirements
10. Section 079219 – Acoustical Sealants
11. Section 230548 – Noise and Vibration Control for HVAC Systems
12. Section 230549 – Sound Power Level Limits/ Sound Pressure Level Limits
13. Section 260548 – Noise and Vibration Control for Electrical Systems

1.4 QUALITY ASSURANCE

A. Provide all vibration isolators and equipment bases for Division 22, 23 and 26 work from the product line of a single manufacturer, unless otherwise accepted by the Acoustics Consultant.

B. Select isolators to provide uniform deflections within acceptable tolerances when supporting the equipment approved for this project. Coordinate as required with the equipment manufacturers to accomplish this.

C. Provide engineering, isolator selection, site supervision, and inspection by manufacturer's personnel who shall perform these services directly. Alert the Engineer and Acoustics Consultant of isolator selections that may result in resonances with the equipment and structural systems they are intended to isolate. Replace isolators that upon installation are found to resonate with the supported equipment.

D. Provide complete isolation systems that include all elements recommended by the manufacturer for compliance with project requirements and applicable codes, ordinances, and regulations. Include all incidental products and materials required for a complete installation even if not explicitly described in the Construction Documents.

E. Install vibration isolation systems using skilled workers trained and licensed, as applicable, by the manufacturer for installations of the types used on this project. Upon completion of the Work, provide final inspection by the manufacturer's representative and submit to the Architect and Engineer a written report authored by the manufacturer's representative certifying the correctness of installation and compliance with the approved submittal data. Include tabulation of of the static deflection expected under design and operating loads in comparison with the actual static deflection measured in the completed installations.

F. Seismic Restraint Requirements:

1. Design vibration isolation mounts to meet the current design requirements and codes defined by the Structural Engineer. Use appropriate equipment weights and force factors for the equipment used in this project.

2. Provide certification by a licensed professional engineer experienced in the design of restraints for resiliently mounted equipment, and in the employ of the manufacturer, stating that the requirements of all applicable codes, ordinances and regulations regarding seismic restraint of resiliently mounted equipment have been met by the design. Provide shop drawings, calculations, and analysis stamped by the manufacturer's engineer and demonstrating this compliance.

G. Wind Bracing Requirements:

1. Design vibration isolation mounts to meet the design wind loads defined by the Structural Engineer and required by applicable codes. Provide calculations and certification stating compliance.

1.5 UNACCEPTABLE TYPES

A. Do not used housed spring mounts on this project. Mason models C, CI, and CS; Amber-Booth models Xl and XK; Kinetics SL and SM; and similar mounts are not acceptable.

B. Do not use captive spring mounts on this project. Provide seismic restraint by means of resilient snubbers at the perimeter of the equipment or equipment base and not by mounts that combine isolation and snubbing functions. Mason model SSLFH, Amber-Booth model SWPQ, and similar mounts are not acceptable.

C. Do not use cork as an isolation material.

D. Do not use braided metallic hose for vibration isolation in piping unless fluid temperatures and pressures are beyond the service range of spherical elastomeric isolators.

1.6 STANDARDS

A. American Association of State Highway Transportation Officials (AASHTO) Standard Specifications for Highway Bridges, Highway Bridge Specification, Table B: Requirements for Physical Properties of Bridge-Bearing Quality Neoprene.

1.7 ENGINEERING

A. The Construction Documents are indicative of isolation requirements. Provide complete engineering services for all components of isolation systems used in this project.

1.8 SUBMITTALS

A. Submit manufacturer's data, shop drawings, and product performance certifications in accordance with Division 1.

B. Manufacturer's Data: Submit technical product data confirming that products comply with specified requirements:

1. Illustrations and descriptions of components including, but not limited to isolators, equipment bases, thrust and seismic restraints, anchors, and accessories.

2. Operation and maintenance instructions.

C. Shop Drawings

1. Full-size details of isolation systems, including plan and section drawings indicating isolator and flexible connection locations and types, isolator and connector schedules, details for resilient penetrations, and installation details.

2. Indicate substrate construction required of other subcontractors.

D. Color code legend for spring and elastomer capacities.

E. Samples: provide a sample of each type of isolator assembly used in the project. It is not necessary to submit samples of each spring capacity and pad hardness.

F. Calculations: submit manufacturer's engineer's calculations of loads, deflections, and natural frequencies for record only.

G. Certifications: provide the following:

1. Certification that elastomeric pads meet the requirements of AASHTO Highway Bridge Specification.

H. Supervision plan for manufacturer's representative in the field during installation of vibration isolation systems.

I. General Requirements for Vibration Isolation Mounts and Hangers: Provide catalog cut sheets, shop drawings, and other documents as necessary to describe the installation and its components. Include the following information:

1. Springs:

a. Equipment name and number
b. Operating Weight of Equipment
c. Lowest reciprocating or rotating speed
d. Isolator type
e. Weight supported by isolator
f. Scheduled deflection
g. Proposed deflection under operating load
h. Natural Frequency
i. Spring free height
j. Spring operating height
k. Spring solid height at coil bind
l. Spring diameter

2. Elastomeric Pads:

a. Equipment name and number
b. Operating Weight of Equipment
c. Isolator type
d. Weight supported by isolator
e. Pad bearing area
f. Pad free height
g. Pad operating height
h. Scheduled deflection
i. Proposed deflection under operating load
j. Percent deflection
k. Natural Frequency
l. Hardness and compliance with AASHTO Bridge Bearing Neoprene quality standard

PART 2- PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers listed below have demonstrated an ability to comply with specifications for vibration isolation products similar to those required for this project. However, specific products made by the listed manufacturers do not all comply with the requirements of this specification. Subject to the requirement for a single manufacturer and the restrictions regarding unacceptable types of isolators, the products of the following manufacturers are acceptable sources for this project:

1. Mason Industries, Inc., Hauppage, New York
2. Kinetics Noise Control, Dublin, Ohio
3. Amber-Booth Company, Inc., Houston, Texas
4. E.A.R., Indianapolis, Indiana
5. PSI-Thunderline/Link-Seal, Houston, Texas
6. Ductmate Industries, Inc., East Monongahela, PA

2.2 SPRING REQUIREMENTS

A. Provide steel springs with static deflections equal to or greater than those shown on the Construction Documents. Submittals based on rated deflections will be rejected.

B. Unless otherwise noted, size springs to provide a natural frequency of not more than 3 Hertz. Where spring deflections called out in the Construction Documents exceed those required to achieve a natural frequency of 3 Hz or less, the greater deflection will govern.

C. Size springs to provide not less than 50 percent additional travel to solid, coil-bind condition beyond the deflection under operating load.

D. Size springs so that diameter is not less than 80 percent of the height of the spring at operating load.

E. Provide springs that do not permanently deflect after loading to a solid, coil-bind condition.

F. Do not weld springs to other components of the isolator assembly unless specifically noted in the Submittals and accepted by the Acoustics Consultant.

G. Color code springs to allow positive identification after installation. Match color coding to the color code legend provided with the submittals.

2.3 ELASTOMER REQUIREMENTS

A. Provide elastomeric elements with static deflections equal to or greater than those shown on the Construction Documents. Submittals based on rated deflections will be rejected.

B. Provide neoprene elements with a maximum hardness of 40 durometer, Shore A rating, where possible, but in no case exceeding 50 durometer. Where deflections called out in the construction documents exceed those required to achieve the specified natural frequencies, the greater deflection will govern.

C. Meet AASHTO Highway Bridge Specifications for all neoprene products installed in irretrievable locations and as required elsewhere in the Construction Documents.

2.4 CORROSION RESISTANCE

A. Treat isolators and associated hardware for resistance to corrosion to the following requirements:

1. Interior exposure:

a. Steel isolator components: PVC coating or phosphate treatment with finish coat of industrial grade enamel paint.
b. Structural steel bases and associated components: Cleaned of welding slag, primed with zinc chromate primer (steel) or metal etching primer (aluminum); industrial grade enamel finish coat.
c. Nuts, bolts, and other fasteners: zinc electroplate with etching primer and enamel paint finish coat.

2. Exterior exposure:

a. Steel components: PVC coating; or hot-dipped or electroplated zinc with neoprene or bitumastic finish coat.
b. Aluminum components: etched and painted with industrial grade enamel paint.
c. Nuts, bolts, and other fasteners: zinc electroplate with etching primer and enamel paint finish coat.

2.5 ACCEPTABLE PRODUCTS

A. (Type P-1) Elastomeric Pads: 5/16-inch minimum thickness, waffled or ribbed neoprene. Where multiple layers are required to provide the specified deflections, interleave pads with 16 gauge steel shim plates. Size pads for deflection equal to 10 to 15 percent of unloaded height and provide pads of sufficient thickness to achieve the specified deflection. Provide load-distributing top plates if required for uniform loading. Acceptable products include

1. Individual pads

a. Mason W, SW, and Super W
b. Kinetics NP
c. Amber-Booth NR

2. Neoprene/Steel composite pads:

a. Mason WSW
b. Amber-Booth SP-NR Style E

B. (Type P-2) Neoprene Base Mount Isolators: Provide double-deflection in-shear isolators with steel bottom plates with pre-drilled bolt holes for attachment to floor or base, a threaded steel insert at the top of the isolator for attaching the equipment, and friction surfaces at both top and bottom. Coat all metal surfaces with neoprene. Design isolators for 0.25 to 0.35 inches of deflection. Acceptable products include:

1. Neoprene-In-Shear Isolators:

a. Mason ND
b. Kinetics RD
c. Amber-Booth RVD

C. (Type P-3) Neoprene Wall Mount Isolators: Solid neoprene or neoprene housed in steel casing. Provide threaded insert to receive equipment mounting bolt. Select isolators of not greater than 50 durometer Shoe A hardness to provide a minimum of .10 inch static deflection in shear-mounting condition under operating load. Acceptable products include:

1. Neoprene Wall-Mount Isolators:

a. Mason BR, RBA, and RCA
b. Kinetics RQ

D. (Type P-4) Elastomeric Hangers: Provide neoprene-in-shear element mounted in a rigid steel hanger box. Mold neoprene element with a rod isolation bushing that prevents rigid contact between hanger rod and housing from vertical through an angular deflection of not less than 30 degrees in any direction. Design for .25 to .35 inch minimum static deflection at rated load. For ductwork hung by straps, provide hangers with eyes on the top and bottom to allow for bolting to the straps. Acceptable products include:

1. Elastomeric Hangers:

a. Mason HD and WHD
b. Kinetics RH
c. Amber-Booth BRD

E. (Type P-5) Open Spring Base-Mounted Isolators: Provide isolators of the general characteristics described in paragraph 2.2, above, that are freestanding and laterally stable with no housing and that are furnished with level-adjustment bolts for rigid connection to the isolated equipment. Provide with molded neoprene cup or 1/4 inch thick Type P-1 elastomeric friction pad between isolator baseplate and its support. Size the pads and associated load distribution plates for deflection of 10 to 20 percent of the unloaded thickness of the pads. Vary spring size as required for equal deflection under non-uniformly distributed equipment loads. Acceptable products include:

1. Open Spring Isolators:

a. Mason SLF
b. Kinetics FDS
c. Amber-Booth SW

F. (Type P-6) Restrained Open Spring Base-Mounted Isolators: Provide built-in adjustable spring restraints for equipment with operating weight greater than weight upon installation to prevent equipment from deflecting (or rising) when the additional weight is applied (or removed in the future). Provide isolators as specified for Type P-5 but with restraint studs and adjustable nuts. Provide ½ inch minimum clearance around the restraint studs. Use bridge-bearing quality neoprene for elastomeric friction pads at chillers and cooling towers. Acceptable products include:

1. Restrained Base Mounted Isolators:

a. Mason SLR
b. Kinetics FLS
c. Amber-Booth CT

G. (Type P-7) Spring Hangers: Provide spring of the general characteristics specified in Paragraph 2.2, above in a rigid steel hanger box. Seat spring in a molded neoprene cup with steel washer reinforcing. Mold neoprene element with a rod isolation bushing that prevents rigid contact between hanger rod and housing from vertical through an angular deflection of not less than 15 degrees in any direction. For ductwork hung by straps, provide hangers with eyes on the top and bottom to allow for bolting to the straps. Acceptable products include:

1. Spring hangers:

a. Mason types 30 and W30

H. (Type P-8) Spring/Elastomer-in-Series Hangers: Provide neoprene-in-shear element of 1¼-inch minimum thickness and a spring of the general characteristics specified in Paragraph 2.2, above. Seat spring in a molded neoprene cup with steel washer reinforcing. Mold neoprene element with a rod isolation bushing that prevents rigid contact between hanger rod and housing from vertical through an angular deflection of not less than 15 degrees in any direction. Design neoprene for .25 to .35 inch minimum static deflection at rated load. Do not directly stack the pring and neoprene isolator elements. For ductwork hung by straps, provide hangers with eyes on the top and bottom to allow for bolting to the straps. Acceptable products include:

1. Spring/Elastomer-in-Series Hangers:
    a. Mason 30N
    b. Kinetics SRH
    c. Amber-Booth BSRA

I. (Type P-9) Pre-compressed Spring/Elastomer-in-Series Hangers: Provide built-in adjustable spring restraints for equipment with operating weight greater than weight upon installation to prevent equipment from deflecting (or rising) when the additional weight is applied (or removed in the future). Provide isolators similar to Type H-8, but pre-compressed with restraint mechanisms that can be released to free the spring when subjected to its operational load. Provide an integral scale to indicate amount of deflection. For ductwork hung by straps, provide hangers with eyes on the top and bottom to allow for bolting to the straps. Acceptable products include:

1. Pre-compressed Spring/Elastomer-in-Series Hangers:
    a. Mason PC30N
    b. Amber-Booth PBSRA

J. (Type P-10) Thrust Restraints: When total air or fluid thrust exceeds 10 percent of the isolated weight, provide resilient horizontal thrust restraints to prevent excessive horizontal movement. Provide spring isolators similar to Type P-7 with the same deflection as the isolator springs. Preset thrust restraint isolators in the factory and fine tune in the field to allow for a maximum of ¼ inch deflection between at-rest and maximum-thrust conditions. Furnish with appropriate brackets to attach to equipment and the structure. Install restraints on centerline of thrust and symmetrically on both sides of the equipment. Acceptable products include:

1. Thrust Restraints:
    a. Mason WB

K. (Type P-12) Concrete Inertia Bases: Provide inertia bases of normal weight concrete (150 pcf) and appropriate steel reinforcing within perimeter frames of steel channel, in a rigid assembly that will not twist, deform, deflect, or crack in any manner that would affect the operation of the isolated equipment or the performance of the isolators. Size inertia bases to support equipment housings, motors, and associated pipe and duct elbows, electrical control elements, and any other related components requiring resilient support because of its location on the equipment side of the flexible connections to distribution ductwork and piping. Supply steel frame under this specifications section. Provide concrete under this section or Division 3.

1. Inertia Base sizing requirements: Provide bases with minimum thickness of 6 inches. Increase thickness as required to achieve required mass. Size perimeter steel to be not less than one twelfth of the longest dimension of the base. Space isolators not more than ten times the slab thickness apart. Provide a minimum of 2 inches clearance between floor or housekeeping pad and underside of slab. Use height-saving brackets if required to maintain equipment clearances. Acceptable products include:
    a. Mason types K and BMK

L. (Type P-13) Flexible Neoprene Piping Connectors: Provide flanged twin-sphere or threaded single-sphere isolators with Kevlar cord and peroxide-cured EPDM body with steel rings embedded in flanges to prevent pull-out. Connectors must accept elongation, compression, axial, and transverse motion. Select materials to suit system temperature, pressure, and fluid type. Do not use control rods or cables to limit extension of the isolator. Use twin-sphere isolators for pipes 2 inches to 14 inches in diameter. Single-sphere isolators may be used for pipes less than 2 inches and greater than 14 inches in diameter. Straight-wall flexible connectors are not acceptable except for sewage ejector pumps. Acceptable products include:

1. Flexible Neoprene Piping Connectors:
    a. Mason types SFDEJ, SFDCR, and SFU

M. (Type P-14) Elastomeric Isolators for Mounting Bolts: Provide neoprene grommets, bushings, and washers for all bolts used to secure isolators to floors and housekeeping slabs and for all snubbers. Size bolt holes and washers to accommodate grommets, sleeves, and bushings and to preclude contact between rigid components that would cause bridging between isolated elements and the building structure. Baseplates for neoprene pads may be rigidly bolted to the floor or housekeeping slab if the bolts secure the baseplates only and do not continue through the neoprene to meet any other rigid material. Do not exceed 40 durometer, Shore A hardness. Acceptable products include:

1. Grommets (Washer Bushings):
   a. Mason HG
   b. E.A.R. Isodamp and C-1000
2. Bushings:
   a. Mason HLB
3. Washers:
   a. Mason HLW

PART 3- EXECUTION

3.1 GENERAL

A. Before commencing installation examine the substrate and surrounding conditions to insure that there is nothing to prevent proper and timely execution of the installation. Beginning work specified in this Section indicates acceptance of the substrate and surrounding conditions.

B. Install isolation systems in strict compliance with manufacturer's recommendations and engineering, and submittal data. Make no rigid connections to structure that would compromise the performance of the isolation systems.

C. Resiliently mount or hang mechanical equipment, ductwork, piping, and other equipment on structural components indicated on the Drawings and as specified in this section.

D. For all isolated equipment, make connections of piping, ductwork, and conduit using flexible connections specified in this section. Make no connections to isolated equipment in a manner that would compromise the performance of the isolation systems. Refer to Section 230548 – Noise and Vibration Control for Electrical Systems for requirements related to isolation of electrical equipment and connections.

E. Install seismic restraints and sway bracing in conformance with the engineered shop drawings and applicable codes, ordinances, and regulations.

F. Establish isolator locations for ease of installation, adjustment, and inspection as well as specified performance.

G. Replace isolators found to resonate with building structure, at no additional cost to the Owner.

3.2 GENERAL REQUIREMENTS FOR MOUNTS AND HANGERS

A. Align mounts and hangers squarely above or below the equipment mounting holes to avoid introducing lateral loads and deflection.

B. Deflection requirements:
   1. Verify installed isolators have deflections equal to or greater than deflections specified on the submittals.
   2. Where multiple deflections apply to a single isolator (where a single isolator supports multiple isolated elements), the largest deflection governs.
   3. Vary the size and/or hardness of isolators as required to yield equal deflection for all isolators supporting a single piece of equipment or length of pipe or ductwork. Consult manufacturer for direction when specified isolators do not yield required deflection and correct non-compliant isolators at no cost to the Owner.

C. Support equipment, ductwork, conduit and piping independently. Do not hang equipment, ductwork, piping, or conduit from other isolated equipment, ductwork, piping, or conduit.

D. Maintain 2 inches of clearance between isolated elements and walls, ceilings, and other non-isolated building components.

E. Isolate drain piping attached to vibration isolated equipment from rigid components of the building.

F. Limit stops must be inactive and out of contact with the isolator during equipment operation.

G. Adjust leveling bolts and hanger rod lengths so that equipment is level and in alignment with connecting ductwork and piping.

H. Restrained isolators may be substituted for unrestrained isolators at installer's option to simplify installation.

I. Isolate hanger rods passing through barrier ceilings with elastomeric sleeves or grommets or treat as resilient penetrations in accordance with the details and Section 079219 – Acoustical Sealants. Unless noted otherwise, locate equipment, piping, and ductwork below barrier ceilings.

3.3 EQUIPMENT MOUNTED ON FLOORS, HOUSEKEEPING PADS, AND STRUCTURAL ELEMENTS

A. Do not rigidly mount any equipment having rotating or reciprocating components. Provide ¾-inch neoprene waffle pads beneath equipment installed on floors and housekeeping slabs without curbs or equipment bases.

B. For equipment with bases, locate isolators on the sides of the base that are parallel to the equipment shaft.

C. At housekeeping slabs and pedestals, position isolators with entire bearing plate on slab or pedestal. Do not cantilever baseplates beyond edges of slabs and pedestals. Coordinate isolator locations with housekeeping slabs so that outboard height-saving mounts do not contact the housekeeping slabs. Notify contractor of work by others requiring remediation for proper installation of isolators.

D. For floor-mounted equipment, provide a minimum of 2 inches operating clearance from the lowest point of the base to the floor or housekeeping slab. Verify that 2 inches of unobstructed clearance has been provided in the final installation under operating loads. Correct nonconforming conditions at no cost to the Owner. Provide height-saving brackets as required to maintain required equipment clearances.

E. For concrete inertia bases, set steel perimeter on bond breaker material, provide steel reinforcing in compliance with Manufacturer's recommendations, and pour normal weight concrete to the full depth of the perimeter steel. If no reinforcing is specified, provide ½-inch reinforcing bar at 6-inch centers each way, and weld reinforcing to the perimeter steel 1½ inches above the bottom of the steel. Provide required anchor bolts held in position by steel templates during the pour.

F. Domestic Hot Water Boilers:

1. Provide Type P-1 isolators in multiple layers as required to achieve not less than .25 inch static deflection.
2. Provide Type P-14 sleeves, bushings, grommets, and washers as recommended by the isolator manufacturer to hold isolators in place while preventing rigid short-circuits of the isolation system.
3. Secure piping and conduits with resilient connections specified elsewhere in this section and in Section 260548 – Noise and Vibration Control for Electrical Systems.
4. Treat breeching and flues as isolated ductwork for their entire lengths, including roof penetrations.

G. Sump and Ejector Pumps:

1. Mount on Type P-1 neoprene pads using Type P-14 bolt isolation. Provide Type P-13 double-sphere isolators at piping connections for sump pumps and straight-wall flexible connections for ejector pumps.

H. Elevator Equipment:

1. Mount hydraulic pumps and oil storage tanks on Type P-1 multi-layer bridge-bearing neoprene pads or Type P-2 neoprene base mount isolators. Size isolators for not less than .25 inch static deflection.
2. Connect hydraulic lines using braided stainless steel hose installed parallel to the equipment drive shafts. Provide hose length not less than 20 times its diameter.
3. Isolate entire length of hydraulic lines from the building structure using Type P-1 bridge-bearing neoprene pads.
4. Provide flexible conduit connections as specified in Section 260548 – Noise and Vibration Control for Electrical Systems.

I. Jockey Pumps:

1. Bolt base-mounted jockey pumps to Type P-12 concrete inertia bases with Type P-6 restrained open spring base isolators.
2. Connect to piping with Type P-13 double-sphere isolators.
3. Provide flexible electrical connections as specified in Section 260548 – Noise and Vibration Control for Electrical Systems.

3.4 SUSPENDED EQUIPMENT

A. In-Line Pumps:

1. Resiliently hang in-line jockey pumps on Type P-8 spring/elastomer-in-series hangers.
2. Connect to piping with Type P-13 double-sphere isolators
3. Provide flexible electrical connections as specified in Section 260548 – Noise and Vibration Control for Electrical Systems.

3.5 PIPING AND CONDUIT ISOLATION

A. Isolate all piping 1½ inches and larger in diameter that is connected to rotating or reciprocating equipment. Waste, vent, rainwater, and fire protection piping do not require isolation unless noted otherwise.

B. Select and install isolators in a manner that does not induce stresses in piping connections and does not result in misalignment of shafts and bearings. Maintain equipment and piping in rigid condition during installation. Do not transfer loads to the isolators until the installation is complete and under full operational load.

C. Isolator Types:

1. For equipment isolated with supports and mounts containing springs, provide Type P-8 or P-9 spring/elastomer-in-series isolators for the first 4 horizontal piping hangers and associated vertical piping. Size these hangers to provide the same static deflection as the isolators for the equipment. For floor-supported piping, use Type P-6 open spring base mount isolators and Type P-2 neoprene base mount isolators.
2. Beyond the 4 hangers nearest the equipment, within the rooms housing the equipment and for a distance of not less than 50 feet from the equipment, provide Type P-7 elastomeric hangers, and provide Type P-7 hangers for all piping of 2-inch and smaller diameter and flow rates of greater than 4 feet per second.
3. For pipes larger than 2-inch and not greater than 6-inch diameter throughout the building, support entire length on Type P-7 elastomeric hangers, Type P-2 neoprene base mount isolators, or Type P-1 elastomeric pads between the piping and all points of contact between piping and non-isolated construction.
4. For pipes larger than 6-inch diameter, support entire length throughout the building on Type P-9 restrained spring/elastomer-in-series hangers, or Type P-6 restrained spring/elastomer-in-series base mounts if supported from the floor.
5. Vertical Piping:
    a. Support vertical piping 2-inch diameter and larger on Type P-6 restrained spring/elastomer-in-series base mounts for the first 3 support points nearest the equipment.
    b. Support all other vertical piping of 2-inch and smaller diameter within 50 feet of connected equipment on Type P-2 neoprene base mount isolators.
    c. For vertical pipes larger than 2-inch diameter and not greater than 6-inch diameter throughout the building, support on Type P-2 neoprene base mounts.
    d. Support all vertical piping greater than 6-inch diameter throughout the building on Type P-6 restrained spring/elastomer-in-series base mounts.

D. Position isolators as high as possible in the hanger rod or strap assembly but not in direct contact with the building structure without manufacturer's written authorization. Provide 1 inch minimum clearance between isolator housing and structure above. Provide side clearance for hangers to allow full 360-degree rotation about the rod axis without contacting any object.

E. Parallel pipes can be hung together on a trapeze that is isolated from the structure. Isolator deflections must be equal to or greater than the greatest deflection required for the pipes if isolated individually. Do not mix isolated and non-isolated piping on the same trapeze.

F. Mount flexible connections for piping to equipment on the equipment side of shut-off valves.

G. Provide isolation of expansion tanks, air separators, and other devices similar to that provided for the attached piping.

3.6 THRUST RESTRAINTS

A. Protect pumps from excessive deflection with appropriate thrust restraints. All bracing and restraints must be engineered by the manufacturer and included in the submittals.

3.7 PENETRATIONS OF STRUCTURE, PARTITIONS, AND CEILINGS

A. Provide resilient penetration seals for all plumbing penetrations of walls floors, and ceilings of equipment rooms, all rooms classified as Acoustically Sensitive in Section 018601 – General Acoustic Requirements and elsewhere as required by the Construction Documents. Provide the following:

1. 22 gauge steel sleeve grouted rigidly in place in all wall, floor, and ceiling locations; except that sleeves may be omitted at properly sized cored or sleeved penetrations through solid concrete, solid or grouted masonry walls. And hollow partitions in which solid blocking has been placed for coring of penetrations. Size sleeves and cored holes to provide annular space of ½ to ¾ inch width around conduit. Center the conduit in the sleeve or penetration.
2. Pack the annular space with lose glass- or mineral-fiber insulation to the full depth of the wall or floor/ceiling construction. Seal completely between sleeve and conduit with Acoustical Sealant installed in accordance with Section 079219 – Acoustical Sealant.

3.8 TESTING, EVALUATION AND ACCEPTANCE PROCEDURES

A. If it is found that the construction fails the acoustic test measurements or performance requirements identified in the Contract Documents, make changes necessary to meet the requirements identified in the Contract Documents and be responsible for the costs associated with performing all additional acoustical tests to verify the acoustic performance of the construction. Costs for additional acoustical testing shall include consulting fees at per hour rates in effect at the time of testing along with related expenses including, but not limited to, travel expenses and test equipment use charges.

END OF SECTION

IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Stencils.
5. Valve tags.
6. Warning tags.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:
1. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving**,** 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: Yellow.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to full circumference of pipe.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches.

2.4 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
   1. Stencil Material: Aluminum.
   2. Stencil Paint: Exterior, gloss, alkyd enamel, colors as indicated. Paint may be in pressurized spray-can form.
   3. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1 2007 unless otherwise indicated.
      a. Exposed waste and vent to be stenciled with yellow letters on cast iron and black letters on galvanized and copper.
      b. Exposed storm piping to be stenciled with white letters on cast iron and black letters on galvanized and copper.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass beaded chain.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Valve-tag schedule shall be included in operation and maintenance data.

2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: 4 by 7 inches.
   2. Fasteners: Brass grommet and wire Reinforced grommet and wire or string.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
   4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09 Section "Interior Painting High-Performance Coatings."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles , complying with ASME A13.1, on each piping system.
   1. Identification Paint: Use for contrasting background.
   2. Stencil Paint: Use for pipe marking.

C. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 20 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
   7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Pipe Label Color Schedule:
   1. Low-Pressure, Compressed-Air Piping:
      a. Background Color: White.
      b. Letter Color: Blue.
   2. Medium-Pressure, Compressed-Air Piping:
      a. Background Color: White.
      b. Letter Color: Red.
   3. Domestic Water Piping:
      a. Background Color: Blue.
      b. Letter Color: White.
   4. Sanitary Waste and Storm Drainage Piping:
      a. Background Color: Black .
      b. Letter Color: Yellow.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
   1. Valve-Tag Size and Shape:
      a. Cold Water: 2 inches, round.
      b. Hot Water: 2 inches, round.
      c. Low-Pressure Compressed Air: 2 inches, square.
      d. High-Pressure Compressed Air: 2 inches, square.

2. Valve-Tag Color:
   a. Cold Water: Blue.
   b. Hot Water: Red.
   c. Low-Pressure Compressed Air: White.
   d. High-Pressure Compressed Air: White.
3. Letter Color:
   a. Cold Water: White.
   b. Hot Water: White.
   c. Low-Pressure Compressed Air: Blue.
   d. High-Pressure Compressed Air: Red.

3.5 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION

PLUMBING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Insulation Materials:
      a. Mineral fiber.
      b. Rigid preformed.
   2. Insulating cements.
   3. Adhesives.
   4. Mastics.
   5. Sealants.
   6. Field-applied jackets.
   7. Tapes.
   8. Securements.

1.3 1.3 DEFINITIONS

A. Hot Surfaces: Normal operating temperatures of 100 deg F or higher.

B. Cold Surfaces: Normal operating temperatures less than 75 deg F.

C. Thermal Resistivity: "r-values" represent the reciprocal of thermal conductivity (k-value). Thermal conductivity is the rate of heat flow through a homogeneous material exactly 1 inch thick. Thermal resistivities are expressed by the temperature difference in degrees F between two exposed faces required to cause one Btu to flow through one square foot of material, in one hour, at a given mean temperature.

D. Density: Is expressed in lb/cu.ft.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application and equipment Installer for equipment insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Sealants, mastics and adhesives shall have volatile organic compounds (VOC) levels which adhere to the LEED Indoor Environmental Quality IEQ credits criteria.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

1.9 WARRANTY

A. Provide warranty on materials and labor for 18 months starting from date of delivery, or one year from date of preliminary acceptance, whichever is longer.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Mineral-Fiber, Preformed Pipe Insulation:
1. Products: Subject to compliance with requirements:
a. Fibrex Insulations Inc.; Coreplus 1200.
b. Johns Manville; Micro-Lok.
c. Knauf Insulation; 1000(Pipe Insulation.
d. Manson Insulation Inc.; Alley-K.
e. Owens Corning; Fiberglas Pipe Insulation.
2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

F. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article. The R value shall be a minimum of 3.0.
1. Products: Subject to compliance with requirements:
a. CertainTeed Corp.; CrimpWrap.
b. Johns Manville; MicroFlex.
c. Knauf Insulation; Pipe and Tank Insulation.
d. Manson Insulation Inc.; AK Flex.
e. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

C. ASJ Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

D. PVC Jacket Adhesive: Compatible with PVC jacket.

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
1. Products: Subject to compliance with requirements:
2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
1. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
2. Service Temperature Range: Minus 20 to plus 200 deg F.
3. Solids Content: 63 percent by volume and 73 percent by weight.
4. Color: White.

2.4 SEALANTS

A. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.5 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

2.6 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
1. Adhesive: As recommended by jacket material manufacturer.
2. Color: White.
3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
4. Factory-fabricated tank heads and tank side panels.

C. Underground Direct-Buried Jacket: 125-mil- thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

2.7 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
1. Width: 2 inches.
2. Thickness: 6 mils.
3. Adhesion: 64 ounces force/inch in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.

2.8 SECUREMENTS

A. Bands:
1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 316 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing seal.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal.

B. Insulation Pins and Hangers:
1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
b. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Wire: 0.080-inch nickel-copper alloy 0.062-inch soft-annealed, stainless steel 0.062-inch soft-annealed, galvanized steel.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
      a. For below ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.
   4. Manholes.
   5. Handholes.
   6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
   4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   1. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 7 Section " Through-Penetration Firestop Systems "

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for **100** percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
a. Do not weld anchor pins to ASME-labeled pressure vessels.
b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
d. Do not overcompress insulation during installation.
e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
f. Impale insulation over anchor pins and attach speed washers.
g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

3.6 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times

the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

3.7 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

4. Install insulation to flanges as specified for flange insulation application.

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
   1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.9 EQUIPMENT INSULATION SCHEDULE

A. INTERIOR DOMESTIC HOT WATER AND RECIRCULATED HOT WATER UP TO 140°F

Type	RUNOUTS TO FIXTURES, 12' MAX LENGTH	3/4" TO 1"	1-1/4" AND LARGER	FIELD-APPLIED JACKET
Rigid preformed sections in exposed areas.	1"	1"	1-1/4"	ASJ
Mineral fiber semi-rigid preformed sections in concealed areas	1"	1"	1-1/4"	ASJ

B. INTERIOR DOMESTIC COLD WATER

Type	RUNOUTS TO FIXTURES, 12' MAX LENGTH	1/2" TO 1"	1-1/4" AND LARGER	FIELD-APPLIED JACKET
Rigid preformed sections in exposed areas.	1"	1"	1"	ASJ
Mineral fiber semi-rigid preformed sections in concealed areas	1"	1"	1"	ASJ

C. INTERIOR STORM DRAINAGE AND SUSPENDED WASTE PIPING ABOVE OCCUPIED AREAS.

Type	SIZES	FIELD-APPLIED JACKET
Rigid preformed sections in exposed areas.	ALL	PVC
Mineral fiber semi-rigid preformed sections in concealed areas	ALL	PVC

END OF SECTION

PLUMBING SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 OWNER FURNISHED

A. See Section 01 91 13 – General Requirements - Commissioning

1.2 RELATED DOCUMENTS

A. All drawings and general provisions of the contract, including all other Division 01 and general and supplementary conditions.

B. Section 01 91 13 – General Requirements – Commissioning

1.3 SUMMARY

A. The purpose of the commissioning process is to provide the owner/operator of the facility with a high level of assurance that the listed plumbing and domestic hot water systems have been installed in the prescribed manner, and operate within the performance guidelines set in the Contract Documents. The Commissioning Authority (CA) shall provide the owner with an unbiased, objective view of the system's installation, operation, and performance. This process is not intended to take away or reduce the responsibility of the design team or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems for beneficial use by the owner. The CA will be a member of the construction team, administrating and coordinating commissioning activities with the design team, construction manager, subcontractors, manufacturers and equipment suppliers.

1.4 REFERENCES

A. See Section 01 91 13 – General Requirements - Commissioning

1.5 SCOPE

A. See Section 01 91 13 – General Requirements - Commissioning

1.6 PLUMBING SYSTEMS / EQUIPMENT INCLUDED IN THE COMMISSIONING PROCESS

A. Domestic Hot Water Heaters

B. Domestic Hot Water Tanks

C. Domestic Hot Water Pumps

D. Domestic Hot Water Valves and Piping

E. Sensor-operated Plumbing Fixture Faucets and Flush Valves

PART 2 - COMMISSIONING PLAN

2.1 COMMISSIONING PLAN DOCUMENT

A. See Section 01 91 13 – General Requirements - Commissioning

2.2 COMMISSIONING TEAM

A. See Section 01 91 13 – General Requirements - Commissioning

2.3 CONTRACT DOCUMENT

A. See Section 01 91 13 – General Requirements - Commissioning

2.4 COMMISSIONING MEETINGS

A. See Section 01 91 13 – General Requirements - Commissioning

2.5 MASTER FINDINGS LIST

A. The Commissioning Authority (CxA) or installing contractor will complete Pre-Functional Testing. Commissioning Agent conducts Functional Testing with assistance of installing contractor.

B. All findings from these inspections are documented and are posted to the master findings list and website within two business days.

C. The Construction Manager (CM) will regularly distribute findings list to contractors and will hold contractor accountable to: 1.) correct any items and/or 2.) provide electronic responses for each finding.

D. The responsible contractor will correct finding(s) and provide written confirmation that the finding(s) have/has been corrected. If finding was not corrected, contractor provides written explanation.

E. Commissioning findings' status may be considered during the pay application approval process. Approval may be withheld due to unresolved findings and/or findings where written responses have not been provided.

F. The CM provides responses back to CxA. All responses are updated to the Master Findings List.

G. Once written responses are provided for each finding, the CxA will re-inspect. The contractor will be back-charged at a rate not to exceed the CxA contract hourly rate for any finding(s) that was/were reported to have been resolved and that are found to be unresolved upon re-inspection.

H. Status will be tracked for each finding and the Master Findings List will be updated accordingly.

I. Once all findings have been resolved and the job is completed, a Final Report will be generated and a final commissioning meeting will be held.

2.6 PRE-FUNCTIONAL TESTING / MANUFACTURER'S CHECKLISTS

A. The Commissioning Authority (CxA) or installing contractor will complete the Pre-Functional Testing forms for each piece of equipment prior to start-up.

B. The equipment manufacturers' checklists must be completed by the installing contractor and reviewed by the Commissioning Authority before start-up can commence.

2.7 START-UP

A. Start-up of major Domestic Hot Water systems may be witnessed by the Commissioning Authority. The appropriate contractors and/or manufacturer's representative will be required on site to perform start-up. No system will be started until the appropriate Start-up Verification Checklists (SVC's) have been completed. No system will be started until the Manufacturer's checklists have been completed. Start-up will be performed according to the Manufacturer's recommended procedures. The Commissioning Authority will visit the site to review completeness of installation in conjunction with progress meetings prior to starting domestic hot water equipment.

B. Installing contractors involved in installation, fabrication, manufacture, control, or design of equipment are required to be present at the time of start-up. A factory-authorized technician will be on site to start equipment when required by the specifications. This will minimize delays in bringing equipment on line and expedite acceptable functional performance in accordance with the Design Intent documents.

2.8 FUNCTIONAL TESTING

A. The Commissioning Authority will perform or witness installing contractor, or manufacturer's representative performing Functional Testing based on the Owner's Project Requirements (OPR) and the Basis of Design (BOD). These tests will be completed for domestic hot water systems and subsystems.

B. Each major system will be tested. A random sample of each subsystem will be tested. This may be coordinated and witnessed by the Commissioning Authority and the owner's maintenance staff. Witnessing the Functional Tests will serve as a compliment to the Operation and maintenance training. No Functional Tests will be performed until the TAB report and the control contractor Point Installation Verification Checklists have been submitted and reviewed by the Commissioning Authority.

C. Off-season mode testing will be implemented as necessary to assure conformance with the Basis of Design document (BOD). Installing contractors will be expected to participate as required by the project specifications.

2.9 BUILDING TURN-OVER / OWNER ORIENTATION / USER TRAINING

A. Owner training will be provided by the installing contractor, or manufacturer's representative, and may be witnessed by the Commissioning Authority. This training should include both classroom training and hands-on operational training. The owner may choose to videotape this training for future use. The Commissioning Authority may visit the site during the Turn-Over and Training period to assure that any on-going Domestic Hot Water System related problems are being addressed and corrected in a timely and efficient manner.

B. The Commissioning Authority will assist in the coordination of off-season testing, calibrating, and servicing as specified in the contract documents.

2.10 WARRANTY REVIEW

A. The Commissioning Authority will participate in a 10-month walk-through to observe the operation of the domestic hot water system. This will include a review meeting with installer, a discussion of warranty

issues, energy usage, maintenance practices, usage changes, and chronic problems, as well as other issues affecting the owner and the operation of the domestic hot water systems.

PART 3 - EXECUTION

3.1 RESPONSIBILITIES OF PLUMBING SYSTEMS INSTALLER

A. The installing contractor in this division shall include in their quote the cost of participating in the commissioning process.

B. Include requirements for submittal data (including partial load data), O&M data, and training in each purchase order or sub-contract.

C. Assure cooperation and participation of specialty sub-contractors such as sheet metal, piping, refrigeration, and water treatment in commissioning activities.

D. Assure participation of major equipment manufacturers in appropriate startup, training, and testing activities.

E. Attend commissioning specific meetings scheduled by the Commissioning Authority or Construction Manager.

F. Assist and participate with the Commissioning Authority in system verification and performance testing, both Pre-Functional and Functional, to achieve design intent.

G. Prepare preliminary schedule for domestic hot water system inspections, O & M manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, system verification, performance testing, and system completion for use by the Commissioning Authority. Update schedule as appropriate throughout the construction period.

H. Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling startup of Domestic Hot Water equipment.

I. Monitor and respond to the Master Findings List distributed by the Commissioning Authority in writing within five (5) business days in order to expedite corrective actions necessary to achieve design intent. Failure to respond in writing within five business days will result in contractor non-compliance and will warrant the provision of a seventy-two (72) hour notice to comply and/or back charge to the contractor for all necessary corrective work. Items that are reported to have been corrected but that are found not to have been corrected after a maximum of two re-inspections will result in a back charge to the responsible contractor for any subsequent re-inspection that must be performed by the Commissioning Authority in order to verify that the corrective work has been completed.

J. Notify the Commissioning Authority a minimum of two weeks in advance of scheduled system start-up.

K. Schedule vendor and subcontractor provided training sessions as required by project specifications.

L. Provide written notification to the Construction Manager and Commissioning Authority that the following work has been completed in accordance with the project specifications, and that the equipment, systems and sub-systems are operating in accordance with design intent.
   1. Domestic hot water equipment including all tanks, pumps, and valves.
   2. All domestic hot water system and equipment controls.
   3. Plumbing fixtures.

M. Participate in the off-season mode testing as required to achieve design intent.

N. Participate in operation and maintenance training as required by project specifications.

O. Provide a complete set of as-built drawings and operation and maintenance manuals for review. The Commissioning Authority shall review the as-built drawings and Operation and Maintenance manuals concurrently with the design team.

P. Update drawings to as-built condition and review with the Commissioning Authority throughout the construction process.

Q. In the event that any portion of the work to be completed by the domestic hot water system and/or equipment installer is subcontracted, ensure compliance with the commissioning process on the part of any individual(s) performing that work. To that end, ensure that each sub-contractor is provided a copy of this specification.

END OF SECTION

DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
   2. Encasement for piping.
   3. Flexible connectors.

B. Related Section:
   1. Division 22 Section "Facility Water Distribution Piping" for water-service piping outside the building from source to the point where water-service piping enters the building.
   2. Division 22 Section “Common Work Results for Plumbing”.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to SEI/ASCE 7.

1.4 SUBMITTALS

A. Product Data: For the following products:
   1. Transition fittings.
   2. Dielectric fittings.
   3. Flexible connectors.

B. Water Samples: Specified in "Cleaning" Article.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 61 for potable domestic water piping and components.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
   1. Notify Architect and Construction Manager Owner no fewer than five days in advance of proposed interruption of water service.
   2. Do not proceed with interruption of water service without Architect's and Construction Manager's written permission.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM 88, Type K and ASTM B 88, Type L water tube, drawn temper.
   1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
   2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
   3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
5. Copper Pressure-Seal-Joint Fittings:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Viega; Plumbing and Heating Systems.
   b. NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
   c. NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.
6. Grooved-Joint Copper-Tube Appurtenances:
   a. Grooved-End-Tube Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.

B. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.
1. Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

2.3 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
1. Standard-Pattern, Mechanical-Joint Fittings: AWWA C110, ductile or gray iron.
2. Compact-Pattern, Mechanical-Joint Fittings: AWWA C153, ductile iron.
   a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
1. Standard-Pattern, Push-on-Joint Fittings: AWWA C110, ductile or gray iron.
   a. Gaskets: AWWA C111, rubber.
2. Compact-Pattern, Push-on-Joint Fittings: AWWA C153, ductile iron.
   a. Gaskets: AWWA C111, rubber.

C. Plain-End, Ductile-Iron Pipe: AWWA C151.
1. Grooved-Joint, Ductile-Iron-Pipe Appurtenances:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Anvil International.
      2) Victaulic Company.
   b. Grooved-End, Ductile-Iron Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.
   c. Grooved-End, Ductile-Iron-Pipe Couplings: AWWA C606 for ductile-iron-pipe dimensions. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.

2.4 GALVANIZED-STEEL PIPE AND FITTINGS

A. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E Grade B, Standard Weight. Include ends matching joining method.
1. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106/A 106M, Standard Weight, seamless steel pipe with threaded ends.
2. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
3. Malleable-Iron Unions: ASME B16.39, Class 150, hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface, and female threaded ends.
4. Flanges: ASME B16.1, Class 125, cast iron.

2.5 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

E. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493.

F. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.6 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105.

B. Form: Tube.

C. Material: LLDPE film of 0.008-inch minimum thickness.

D. Color: Black or Natural color.

2.7 TRANSITION FITTINGS

A. General Requirements:
1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Cascade Waterworks Manufacturing.
b. Dresser, Inc.; Dresser Piping Specialties.
c. Ford Meter Box Company, Inc. (The).
d. JCM Industries.
e. Romac Industries, Inc.
f. Smith-Blair, Inc; a Sensus company.
g. Viking Johnson; c/o Mueller Co.

2.8 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. EPCO Sales, Inc.
d. Hart Industries International, Inc.
e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
f. Zurn Plumbing Products Group; Wilkins Water Control Products.
2. Description:
a. Pressure Rating: 150 psig at 180 deg F.
b. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. EPCO Sales, Inc.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Factory-fabricated, bolted, companion-flange assembly.
b. Pressure Rating: 150 psig 175 psig minimum 300 psig.
c. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Advance Products and Systems, Inc.
      b. Calpico, Inc.
      c. Central Plastics Company.
      d. Pipeline Seal and Insulator, Inc.
   2. Description:
      a. Nonconducting materials for field assembly of companion flanges.
      b. Pressure Rating: 150 psig Insert pressure.
      c. Gasket: Neoprene or phenolic.
      d. Bolt Sleeves: Phenolic or polyethylene.
      e. Washers: Phenolic with steel backing washers.

E. Dielectric Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Calpico, Inc.
      b. Lochinvar Corporation.
   2. Description:
      a. Galvanized-steel coupling.
      b. Pressure Rating: 300 psig at 225 deg F.
      c. End Connections: Female threaded.
      d. Lining: Inert and noncorrosive, thermoplastic.

F. Dielectric Nipples:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Perfection Corporation; a subsidiary of American Meter Company.
      b. Precision Plumbing Products, Inc.
      c. Victaulic Company.
   2. Description:
      a. Electroplated steel nipple complying with ASTM F 1545.
      b. Pressure Rating: 300 psig at 225 deg F.
      c. End Connections: Male threaded or grooved.
      d. Lining: Inert and noncorrosive, propylene.

2.9 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Flex-Hose Co., Inc.
   2. Flexicraft Industries.
   3. Flex Pression, Ltd.
   4. Flex-Weld, Inc.
   5. Hyspan Precision Products, Inc.
   6. Mercer Rubber Co.
   7. Metraflex, Inc.
   8. Proco Products, Inc.
   9. Tozen Corporation.
   10. Unaflex, Inc.
   11. Universal Metal Hose; a Hyspan company

B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   1. Working-Pressure Rating: Minimum 250 psig.
   2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
   3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

C. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
   1. Working-Pressure Rating: Minimum 250 psig.
   2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
   3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

2.10 SLEEVES

A. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel-Pipe: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized, with plain ends.

C. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.11 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advance Products and Systems, Inc.
2. Calpico, Inc.
3. Metraflex, Inc.
4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.
1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel, with corrosion-resistant coating.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.12 WALL PENETRATION SYSTEMS

A. Available Manufacturers : Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following or equal:
1. SIGMA.

B. Description: Wall-sleeve assembly, consisting of housing and gland, gaskets, and pipe sleeve.
1. Carrier-Pipe Deflection: Up to 5 percent without leakage.
2. Housing: Ductile-iron casting with hub, waterstop, anchor ring, and locking devices. Include gland, bolts, and nuts.
3. Housing-to-Sleeve Gasket: EPDM rubber.
4. Housing-to-Carrier-Pipe Gasket: AWWA C111, EPDM rubber.
5. Pipe Sleeve: AWWA C151, ductile-iron pipe or ASTM A 53/A 53M, Schedule 40, zinc-coated steel pipe.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for pressure-reducing valves.

G. Install domestic water piping level without pitch and plumb.

H. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

I. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

J. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

K. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

L. Install piping adjacent to equipment and specialties to allow service and maintenance.

M. Install piping to permit valve servicing.

N. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.

O. Install piping free of sags and bends.

P. Install fittings for changes in direction and branch connections.

Q. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

R. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.

S. Install thermostats in hot-water circulation piping. Comply with requirements in Division 22 Section "Domestic Water Pumps" for thermostats.

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

E. Soldered Joints: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

F. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
   1. NPS 1-1/2 and Smaller: Fitting-type coupling.
   2. NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

3.5 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 Insert pipe size and Smaller: Use dielectric couplings or nipples unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges flange kits nipples.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.6 FLEXIBLE CONNECTOR INSTALLATION

A. Install flexible connectors in suction and discharge piping connections to each domestic water pump and in suction and discharge manifold connections to each domestic water booster pump.

B. Install bronze-hose flexible connectors in copper domestic water tubing.

C. Install stainless-steel-hose flexible connectors in steel domestic water piping.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment and machines to allow service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
   1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
   2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.
   4. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.

B. Sleeves are not required for core-drilled holes.

C. Permanent sleeves are not required for holes formed by removable PE sleeves.

D. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

E. Install sleeves in new partitions, slabs, and walls as they are built.

F. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.

G. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.

H. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals wall penetration systems specified in this Section.

I. Seal space outside of sleeves in concrete slabs and walls with grout.

J. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

K. Install sleeve materials according to the following applications:

   1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
   2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe.
      a. Extend sleeves 2 inches above finished floor level.

b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

3. Sleeves for Piping Passing through Gypsum-Board Partitions:
   a. Steel pipe sleeves for pipes smaller than NPS 6.
   b. Galvanized-steel sheet sleeves for pipes NPS 6 and larger.
   c. Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.
4. Sleeves for Piping Passing through Concrete Roof Slabs: Steel pipe.
5. Sleeves for Piping Passing through Exterior Concrete Walls:
   a. Steel pipe sleeves for pipes smaller than NPS 6.
   b. Cast-iron wall pipe sleeves for pipes NPS 6 and larger.
   c. Install sleeves that are large enough to provide 1-inch annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
   d. Do not use sleeves when wall penetration systems are used.
6. Sleeves for Piping Passing through Interior Concrete Walls:
   a. Steel pipe sleeves for pipes smaller than NPS 6.
   b. Galvanized-steel sheet sleeves for pipes NPS 6 and larger.

L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestop materials and installations.

3.9 SLEEVE SEAL INSTALLATION

A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.

B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.10 WALL PENETRATION SYSTEM INSTALLATION

A. Install wall penetration systems in new, exterior concrete walls.

B. Assemble wall penetration system components with sleeve pipe. Install so that end of sleeve pipe and face of housing are flush with wall. Adjust locking devices to secure sleeve pipe in housing.

3.11 IDENTIFICATION

A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.

B. Label pressure piping with system operating pressure.

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:
   1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
   2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
      a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
      b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
   3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
   4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:
   1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
   2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
   3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
   5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
   6. Prepare reports for tests and for corrective action required.

D. Domestic water piping will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.13 ADJUSTING

A. Perform the following adjustments before operation:
   1. Close drain valves, hydrants, and hose bibbs.
   2. Open shutoff valves to fully open position.
   3. Open throttling valves to proper setting.
   4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
      a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
      b. Adjust calibrated balancing valves to flows indicated.
   5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
   6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
   7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
   8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.14 CLEANING

A. Clean and disinfect potable and non-potable domestic water piping as follows:

   1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
      b. Fill and isolate system according to either of the following:
         1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
         2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
      c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
      d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Clean non-potable domestic water piping as follows:
   1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.

b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities.

D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.15 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Under-building-slab, domestic water, building service piping, NPS 2 and smaller, shall be one of the following:
1. Soft copper tube, ASTM B 88, Type K; copper solder-joint fittings; and brazed copper pressure-seal fittings joints.
2. Mechanical-joint, ductile-iron pipe; standard- or compact- pattern mechanical-joint fittings; and mechanical joints.

D. Under-building-slab, domestic water piping, NPS 3 and smaller, shall be the following:
1. Soft copper tube, ASTM B 88, Type L; no joints allowed below grade.

E. Aboveground domestic water piping, NPS 3 and smaller shall be the following:
1. Hard copper tube, ASTM B 88, Type L cast- copper solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B 88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.

F. Aboveground domestic water piping, NPS 3-1/2 and larger, shall be the following:
1. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.

END OF SECTION

DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following domestic water piping specialties:
1. Backflow preventers.
2. Water pressure-reducing valves.
3. Temperature-actuated water mixing valves.
4. Strainers.
5. Hose bibbs.
6. Wall hydrants.
7. Water hammer arresters.
8. Air vents.
9. Trap-seal primer valves.

B. Related Sections include the following:
1. Division 22 Section "Meters and Gages For Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Division 22 Section "Domestic Water Piping" for water meters.
3. Division 22 Section "Domestic Water Filtration Equipment" for water filters in domestic water piping.
4. Division 22 Section "Drinking Fountains and Water Coolers" for water filters for water coolers.

1.3 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. NSF Compliance:
1. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. BEECO/Mifab
b. Watts Industries
c. Zurn
2. Standard: ASSE 1001.
3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
4. Body: Bronze.
5. Inlet and Outlet Connections: Threaded.
6. Finish: Chrome.

2.2 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. BEECO
b. Watts Industries, Inc.; Water Products Div.
c. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
6. Accessories:
a. Valves: Ball type with threaded ends on inlet and outlet ofNPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

B. Double-Check Backflow-Prevention Assemblies:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. BEECO/Mifab
b. Watts Industries, Inc.; Water Products Div.
c. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1015.
3. Operation: Continuous-pressure applications, unless otherwise indicated.
4. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
6. Configuration: Designed for horizontal, straight through Insert configuration flow.
7. Accessories:
a. Valves: Ball type with threaded ends on inlet and outlet ofNPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

C. Dual-Check-Valve Backflow Preventers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. BEECO/Mifab
b. Watts Industries, Inc.; Water Products Div.
c. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1024.
3. Operation: Continuous-pressure applications.
4. Body: Bronze with union inlet.

D. Reduced-Pressure-Detector, Fire-Protection Backflow-Preventer Assemblies:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. BEECO/Mifab
b. Watts Industries, Inc.; Water Products Div.
c. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1047 and FMG approved or UL listed.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
5. End Connections: Flanged.
6. Accessories:
a. Valves: Outside screw and yoke gate-type with flanged ends on inlet and outlet.
b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.
c. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

2.3 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Individual-Fixture, Water Tempering Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Powers; a Watts Industries Co.
b. Watts Industries, Inc.; Water Products Div.
c. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1016, thermostatically controlled water tempering valve.
3. Pressure Rating: 125 psig minimum, unless otherwise indicated.

4. Body: Bronze body with corrosion-resistant interior components.
5. Temperature Control: Adjustable.
6. Inlets and Outlet: Threaded.
7. Finish: Rough or chrome-plated bronze.
8. See plumbing plans for additional information and design criteria.

2.4 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:
1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550, epoxy coating for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations, unless otherwise indicated.
5. Perforation Size:
a. Strainers NPS 2 and Smaller: 0.020 inch.
b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
c. Strainers NPS 5 and Larger: 0.10 inch.
6. Drain: Factory-installed.

2.5 WALL HYDRANTS

A. Nonfreeze Wall Hydrants Insert drawing designation if any:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. MIFAB, Inc.
b. Prier Products, Inc.
c. Watts Drainage Products Inc.
d. Zurn Plumbing Products
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
9. Operating Keys(s): Two with each wall hydrant.

2.6 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. AMTROL, Inc.
b. MIFAB, Inc.
c. PPP Inc.
d. Sioux Chief Manufacturing Company, Inc.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Metal bellows Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.7 TRAP-SEAL PRIMER VALVES

A. Supply-Type, Trap-Seal Primer Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. MIFAB, Inc.
b. Sioux Chief Manufacturing Company, Inc.

c. Watts Industries, Inc.; Water Products Div.
2. Standard: ASSE 1018.
3. Pressure Rating: 125 psig minimum.
4. Body: Bronze.
5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

B. Drainage-Type, Trap-Seal Primer Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
2. Standard: ASSE 1044, lavatory P-trap with NPS 3/8 minimum, trap makeup connection.
3. Size: NPS 1-1/4 minimum.
4. Material: Chrome-plated, cast brass.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
3. Do not install bypass piping around backflow preventers.

C. Install balancing valves in locations where they can easily be adjusted.

D. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
1. Install thermometers and water regulators if specified.
2. Install cabinet-type units recessed in or surface mounted on wall as specified.

E. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.

F. Install outlet boxes recessed in wall. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 06 Section "Rough Carpentry."

G. Install hose stations with check stops or shutoff valves on inlets and with thermometer on outlet.
1. Install shutoff valve on outlet if specified.
2. Install cabinet-type units recessed in or surface mounted on wall as specified. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 06 Section "Rough Carpentry."

H. Install nonfreeze, nondraining-type post hydrants set in concrete or pavement.

I. Install freeze-resistant yard hydrants with riser pipe set in concrete or pavement. Do not encase canister in concrete.

J. Install water hammer arresters in water piping according to PDI-WH 201.

K. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

L. Install drainage-type, trap-seal primer valves as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.

M. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
1. Reduced-pressure-principle backflow preventers.
2. Double-check backflow-prevention assemblies.
3. Dual-check-valve backflow preventers.
4. Reduced-pressure-detector, fire-protection backflow-preventer assemblies.
5. Double-check, detector-assembly backflow preventers.
6. Water pressure-reducing valves.
7. Calibrated balancing valves.
8. Primary, thermostatic, water mixing valves.
9. Photographic-process, thermostatic, water-mixing-valve assemblies.
10. Primary water tempering valves.
11. Supply-type, trap-seal primer valves.
12. Trap-seal primer systems.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:
1. Test each reduced-pressure-principle backflow preventer double-check backflow-prevention assembly and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.5 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

END OF SECTION

DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following all-bronze and bronze-fitted centrifugal pumps for domestic cold- and hot-water circulation:
   1. Close-coupled, vertically mounted, in-line centrifugal pumps.

B. Related Sections include the following:
   1. Division 22 Section "Domestic-Water Packaged Booster Pumps" for booster systems.
   2. Division 33 Section "Water Supply Wells" for well pumps.

1.3 SUBMITTALS

A. Product Data: For each type and size of domestic water pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For domestic water pumps to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of domestic water pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CLOSE-COUPLED, VERTICALLY-MOUNTED, IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers:
   1. Bell and Gossett Domestic Pump; ITT Industries.
   2. Marshall Engineered Products Co.
   3. Paco Pumps, Inc.

B. Description: Factory-assembled and -tested, overhung impeller, single-stage, close-coupled, horizontally mounted, in-line centrifugal pumps as defined in HI 1.1-1.2 and HI 1.3; and designed for installation with pump and motor shafts mounted horizontally.

1. Pump Construction: All bronze.
   a. Casing: Radially split, cast iron, with threaded companion-flange connections for pumps with NPS 2 pipe connections and flanged connections for pumps with NPS 2-1/2 pipe connections.
   b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
   c. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
   d. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
   e. Bearings: Oil-lubricated; bronze-journal or ball type.
2. Shaft Coupling: Rigid type if pump is provided with coupling.
3. Motor: Single speed, with grease-lubricated ball bearings. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

C. Capacities and Characteristics:
   1. See plumbing plans for pump capacities and characteristics.

2.3 FLEXIBLE CONNECTORS

A. See division 22 specification, “Domestic Water Piping” for flexible connector information.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Install in-line close-coupled, horizontally mounted, centrifugal pumps with motor and pump shafts horizontal.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps to allow service and maintenance.

C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles. Refer to Division 22 Section "Domestic Water Piping."
   1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
   2. Close-coupled, horizontally mounted, in-line centrifugal pumps.
   3. Install shutoff valve and strainer on suction side of pumps, and check valve and throttling valve on discharge side of pumps. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for domestic water piping and Division 22 Section "Domestic Water Piping Specialties" for strainers.
   4. Install pressure gages at suction and discharge of pumps. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and gage connectors.

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

F. Connect thermostats to pumps that they control.

G. Retain paragraph below if applying controls to limit hot-water storage tank circulation pump operation to qualify for LEED Prerequisite EA 2.

H. Interlock pump with water heater burner and time delay relay.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Check piping connections for tightness.
   3. Clean strainers on suction piping.
   4. Set thermostats for automatic starting and stopping operation of pumps.
   5. Perform the following startup checks for each pump before starting:
      a. Verify bearing lubrication.
      b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
      c. Verify that pump is rotating in the correct direction.
   6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
   7. Start motor.
   8. Open discharge valve slowly.
   9. Adjust temperature settings on thermostats.
   10. Adjust timer settings.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following for soil, waste, and vent piping inside the building:
   1. Adjust list below to suit Project.
   2. Pipe, tube, and fittings.
   3. Special pipe fittings.
   4. Encasement for underground metal piping.

B. Related Sections include the following:
   1. List below products that the reader might expect to find in this Section but are specified elsewhere.
   2. Division 22 Section "Sanitary Sewerage Pumps."
   3. Division 22 Section "Chemical Waste-Systems for Laboratory and Healthcare Facilities" for chemical-waste and vent piping systems.

1.3 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
   1. Revise pressure ratings in two subparagraphs below to suit Project. Coordinate with Division 22 Section "Sanitary Waste Piping Specialties."Division 15 Section "Plumbing Specialties." Soil and waste piping may require higher rating if used in high-rise buildings.
   2. Soil, Waste, and Vent Piping: 10-foot head of water.

1.4 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. Shop Drawings:
   1. Retain subparagraph below if piping is required to withstand specific design loads and Architect either has delegated design responsibility to Contractor or wants to review structural data as another way to verify compliance with performance requirements. Professional engineer qualifications are specified in Division 01 Section "Quality Requirements."Division 1 Section "Quality Requirements."
   2. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.
   3. Retain subparagraph below if sovent drainage system is retained.
   4. Sovent Drainage System: Include plans, elevations, sections, and details.

C. Field quality-control inspection and test reports.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.3 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.

C. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
   1. Couplings in subparagraph below are available in NPS 1-1/2 to NPS 15 (DN 40 to DN 375) and are economical, but may not be suitable for installation in corrosive soil.
   2. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
      a. Manufacturers:
         1) ANACO.
         2) Fernco, Inc.
         3) Ideal Div.; Stant Corp.
         4) Mission Rubber Co.
         5) Tyler Pipe; Soil Pipe Div.

D. Rigid, Unshielded Couplings: ASTM C 1461, sleeve-type, reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.

2.4 COPPER TUBE AND FITTINGS

A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
   1. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

B. Hard Copper Tube: ASTM B 88, Types L and M, water tube, drawn temper.
   1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
   2. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
   3. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

C. Soft Copper Tube: ASTM B 88, Type L, water tube, annealed temper.
   1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.

2.5 SPECIAL PIPE FITTINGS

A. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
   1. Manufacturers:
      a. Cascade Waterworks Mfg. Co.
      b. Mission Rubber Co.

B. Rigid, Unshielded, Nonpressure Pipe Couplings: ASTM C 1461, sleeve-type reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.
   1. Manufacturers:
      a. ANACO.

C. Wall-Penetration Fittings: Compound, ductile-iron coupling fitting with sleeve and flexing sections for up to 20-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
   1. Manufacturers:
      a. SIGMA Corp.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Aboveground, soil and waste piping NPS 3 and smaller shall be any of the following:
   1. Retain one or more of first seven subparagraphs below. If more than one type of material and joining method is used, identify various materials on Drawings and show points of transition from one material to another.
   2. Hubless cast-iron soil pipe and fittings CISPI hubless-piping couplings; and hubless-coupling joints.
   3. Dissimilar Pipe-Material Couplings: Shielded or unshielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
   4. Copper tube, copper drainage fittings, and soldered joints.

B. Aboveground, soil and waste piping NPS 4 and larger shall be the following:
   1. Hubless cast-iron soil pipe and fittings CISPI hubless-piping; and hubless-coupling joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

C. Aboveground, vent piping NPS 3 and smaller shall be any of the following:
   1. Hubless cast-iron soil pipe and fittings; standard, shielded, couplings; and hubless-coupling joints.
   2. Copper tube, copper drainage fittings, and soldered joints.

D. Aboveground, vent piping NPS 5 and larger shall be the following:
   1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

E. Underground, vent piping NPS 3 and smaller shall be any of the following:
   1. Hubless cast-iron soil pipe and fittings; standard, shielded, couplings; and hubless-coupling joints.
   2. Copper tube, copper drainage fittings, and soldered joints.

F. Underground, soil, waste, and vent piping NPS 4 and larger shall be any of the following:
   1. Hubless cast-iron soil pipe and fittings; CISPI cast iron hubless-piping couplings; and hubless-coupling joints.
   2. Dissimilar Pipe-Material Couplings: Shielded or unshielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
   3. Underground piping shall not be smaller than NPS 3.

3.3 PIPING INSTALLATION

A. Sanitary sewer piping outside the building is specified in Division 22 Section "Facility Sanitary Sewers."

B. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."

C. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

D. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.

E. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

F. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.

G. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
   1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

H. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper

size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

I. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

J. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:
   1. Edit three subparagraphs below as required by authorities having jurisdiction.
   2. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
   3. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
   4. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

K. Install engineered soil and waste drainage and vent piping systems as follows:
   1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
   2. Sovent Drainage System: Comply with ASSE 1043 and sovent fitting manufacturer's written installation instructions.
   3. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

L. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

M. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.5 HANGER AND SUPPORT INSTALLATION

A. See division 22 specification, “HANGERS and SUPPORTS FOR PLUMBING PIPING and EQUIPMENT” for hanger and support installation requirements.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:
   1. Edit four subparagraphs below to suit Project.
   2. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
   3. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   4. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
   5. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

3.7 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.

2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.8 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION

SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following sanitary drainage piping specialties:
1. Cleanouts.
2. Floor drains.
3. Air-admittance valves.
4. Roof flashing assemblies.
5. Through-penetration firestop assemblies.
6. Miscellaneous sanitary drainage piping specialties.
7. Flashing materials.
8. Solids interceptors.

B. Related Sections include the following:
1. List below only products that the reader might expect to find in this Section but are specified elsewhere.
2. Division 22 Section "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.
3. Division 22 Section "Plumbing Fixtures" for hair interceptors.
4. Division 22 Section "Healthcare Plumbing Fixtures" for plaster sink interceptors.

1.3 SUBMITTALS

A. Shop Drawings: Show fabrication and installation details for frost-resistant vent terminals.
1. Wiring Diagrams: Power, signal, and control wiring.

B. Field quality-control test reports.

C. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary piping specialty components.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Exposed Metal Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Retain one of two lists of manufacturers below.
b. Manufacturers in list below are for ASME A112.36.2M, cast-iron cleanouts.
c. MIFAB, Inc.
d. Watts Drainage Products Inc.
e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping

4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk or raised-head, cast-iron plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Retain last two subparagraphs above for ASME A112.36.2M cleanouts or subparagraph below for ASME A112.3.1, stainless-steel cleanouts.
8. Closure: Stainless-steel plug with seal.

B. Metal Floor Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Mifab
   b. Watts Drainage Products Inc.
   c. Zurn Plumbing Products Group; Light Commercial Operation.
2. Manufacturers in list below are for ASME A112.36.2M, stainless-steel cleanouts.
3. Retain 12 subparagraphs below for cast-iron or stainless-steel cleanouts complying with ASME A112.36.2M.
4. Standard: ASME A112.36.2M for threaded, adjustable housing cleanout.
5. Size: Same as connected branch.
6. Type: Threaded, adjustable housing.
7. Body or Ferrule: Cast iron.
8. Clamping Device: Not required.
9. Outlet Connection: Inside calk Threaded.
10. Closure: Brass plug with straight threads and gasket Brass plug with tapered threads Cast-iron.
11. Adjustable Housing Material: Cast iron.
12. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
13. Frame and Cover Shape: Round.
14. Top Loading Classification: HeavyDuty.
15. Riser: ASTM A 74, class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. MIFAB, Inc.
   b. Watts Drainage Products Inc.
   c. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Option for drilled-and-threaded plug in first subparagraph below is for a screw for a wall cover plate.
6. Closure: Countersunk or raised-head, drilled-and-threaded brass cast-iron plug.
7. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
8. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. MIFAB, Inc.
   b. Watts Drainage Products Inc.
   c. Zurn Plumbing Products Group; Light Commercial Operation.
2. Standard: ASME A112.6.3.
3. Pattern: Floor drain
4. Body Material: Gray iron.
5. Seepage Flange: Required.
6. Anchor Flange: Required.
7. Outlet: Bottom .

2.3 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Acorn Engineering Company; Elmdor/Stoneman Div.

b. Thaler Metal Industries Ltd.

B. Description: Manufactured assembly made of 4.0-lb/sq. ft., 0.0625-inch-thick, lead flashing collar and skirt extending at least 6 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.
1. Open-Top Vent Cap: Without cap.

C. Coordinate roof flashing with architectural roof assembly and profile.

2.4 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:
1. See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products. Retain one of first two subparagraphs and list of manufacturers below. See Division 01 Section "Product Requirements."Division 1 Section "Product Requirements."
2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
3. Size: Same as connected soil, waste, or vent stack.
4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
5. Fitting in subparagraph below is for use with plastic stacks.
6. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
7. Coating in subparagraph below is for use with corrosion-resistant plastic stacks.
8. Special Coating: Corrosion resistant on interior of fittings.

2.5 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Deep-Seal Traps:
1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.
a. NPS 2: 4-inch- minimum water seal.
b. NPS 2-1/2 and Larger: 5-inch- minimum water seal.
3. Floor-Drain, Trap-Seal Primer Fittings:

4. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
5. Size: Same as floor drain outlet with NPS 1/2 side inlet.

B. Sleeve Flashing Device:
1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 1 inch above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

C. Stack Flashing Fittings:
1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.
3. Copy and edit paragraph and subparagraphs below for each type of vent cap required. If only one type is required, drawing designation may be omitted.
4. Size: Same as connected stack vent or vent stack.

D. Expansion Joints:
1. Standard: ASME A112.21.2M.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected soil, waste, or vent piping.

2.6 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:

1. General Use: 4.0-lb/sq. ft., 0.0625-inch thickness.
2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.
3. Burning: 6-lb/sq. ft., 0.0938-inch thickness.

B. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:
1. General Applications: 12 oz./sq. ft..
2. Vent Pipe Flashing: 8 oz./sq. ft..

C. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.

D. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.

E. Fasteners: Metal compatible with material and substrate being fastened.

F. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

G. Solder: ASTM B 32, lead-free alloy.

H. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

2.7 SOLIDS INTERCEPTORS

A. Solids Interceptors:
1. See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products. Retain one of first three subparagraphs and list of manufacturers below. See Division 01 Section "Product Requirements."Division 1 Section "Product Requirements."
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
4. Retain one of two lists of manufacturers below.
5. Manufacturers in list below are for cast-iron or steel solids interceptors.
6. MIFAB, Inc.
7. Watts Drainage Products Inc.
8. Zurn Plumbing Products Group; Specification Drainage Operation.
9. See floor plans for characteristics and capacities

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
1. Coordinate four subparagraphs and associated subparagraphs below with Drawings.
2. Position floor drains for easy access and maintenance.
3. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.

b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.

4. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

F. Install stack air-admittance valves at top of stack vent and vent stack piping.

G. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

H. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

I. Install through-penetration firestop assemblies in plastic conductors and stacks at floor penetrations.

J. Install deep-seal traps on floor drains and other waste outlets, if indicated.

K. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
2. Size: Same as floor drain inlet.

L. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

M. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

N. Install solids interceptors with cleanout immediately downstream from interceptors that do not have integral cleanout on outlet. Install trap on interceptors that do not have integral trap and are connected to sanitary drainage and vent systems.

O. Install wood-blocking reinforcement for wall-mounting-type specialties.

P. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

Q. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 07 Section "Sheet Metal Flashing and Trim."

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
   1. Solids interceptors.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SANITARY SEWERAGE PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following sewage pumps and accessories for sanitary drainage piping systems in buildings:
   1. Wet-pit-mounted, vertical sewage pumps.
   2. Sewage pump reverse-flow assemblies.
   3. Sewage pump basins.

B. Related Sections include the following:
   1. Division 22 Section "Facility Packaged Sewage Pumping Stations" for applications in site-construction sewage pumping.
   2. Division 22 Section "Sump Pumps" for applications in storm-drainage systems.

1.3 SUBMITTALS

A. Product Data: For each type and size of sewage pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For each sewage pump to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of sewage pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 WET-PIT-MOUNTED, VERTICAL SEWAGE PUMPS

A. Available Manufacturers:
   1. Metropolitan.

B. Description: Factory-assembled and -tested, single-stage, centrifugal, end-suction sewage pumps complying with UL 778. Vertical, separately coupled, suspended pumps complying with HI 1.1-1.2 and HI 1.3 for wet-pit-volute sewage pumps and with reverse-flow assembly.
   1. Pump Arrangement: Duplex.

2. Casing: Cast iron, with open inlet and threaded connection for NPS 2 and smaller and flanged connection for NPS 2-1/2 and larger discharge piping.
3. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, open or semiopen, nonclog design for solids handling; overhung, single suction, and keyed and secured to shaft.
4. Pump Shaft and Sleeve Bearings: Stainless-steel shaft with bronze sleeve bearings. Include oil-lubricated, intermediate sleeve bearings at 48-inch maximum intervals if basin depth is more than 48 inches, and grease-lubricated, ball-type thrust bearings.
5. Pump and Motor Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.

C. Pump Discharge Piping: Manufacturer's standard galvanized-steel or bronze pipe.

D. Basin Cover: Cast iron or coated steel and strong enough to support pumps, motors, and controls. See Part 2 "Sewage Pump Basins" Article for requirements.

E. Cover Shaft Seal: Stuffing box, with graphite-impregnated braided-yarn rings and bronze packing gland.

F. Motor: Single-speed; grease-lubricated ball bearings. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."
1. Mounting: On vertical, cast-iron pedestal.

G. Controls: NEMA 250, Type 1 enclosure, pedestal-mounted float switches; with floats, float rods, and rod buttons.
1. Float Guide: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches .
2. High-Water Alarm: Cover-mounted, mechanical-float-switch alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

H. Capacities and Characteristics:
1. See Sump Pump Schedule on plumbing plans for general pump characteristics and electrical capacities.

2.3 SEWAGE PUMP BASINS

A. Description: Factory fabricated basin with sump, pipe connections, and separate cover.

B. Sump: Fabricate watertight, with sidewall openings for pipe connections.
1. Material: Fiberglass.
2. Reinforcement: Mounting plates for pumps, fittings, guide-rail supports, and accessories.
3. Anchor Flange: Same material as or compatible with sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.

C. Cover: Fabricate with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
1. Material: Steel with epoxy coating.
2. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

D. Capacities and Characteristics:
1. Discharge Size: 4”
2. See Sewage Ejector schedule on plumbing plans for basin dimensional information.

2.4 FLEXIBLE CONNECTORS

A. Description: 125-psig minimum working-pressure rating and ends matching pump connections:
1. Bronze Flexible Connectors: Corrugated, bronze inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze-welded to tubing.
2. Stainless-Steel Flexible Connectors: Corrugated, stainless-steel inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to tubing.

2.5 BUILDING AUTOMATION SYSTEM INTERFACE

A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:
1. On-off status of each pump.
2. Alarm status.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for plumbing piping to verify actual locations of sanitary drainage and vent piping connections before sewage pump installation.

3.2 CONCRETE

A. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Division 22 Section "Common Work Results for Plumbing."
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Cast-in-place concrete materials and placement requirements are specified in Division 03 .

3.3 INSTALLATION

A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

B. Install sewage pumps according to applicable requirements in HI 1.4.

C. Install pumps and arrange to provide access for maintenance including removal of motors, impellers, couplings, and accessories.

D. Suspend wet-pit-mounted, vertical sewage pumps from basin covers. Make direct connections to sanitary drainage piping.

E. Install sewage pump basins and connect to drainage and vent piping. Brace interior of basins according to manufacturer's written instructions to prevent distortion or collapse during concrete placement. Set basin cover and fasten to basin top flange. Install cover so top surface is flush with finished floor.

F. Construct sewage pump pits and connect to drainage and vent piping. Set pit curb frame recessed in and anchored to concrete. Fasten pit cover to pit curb flange. Install cover so top surface is flush with finished floor.

G. Install packaged, submersible sewage pump units and make direct connections to drainage and vent piping.

H. Install packaged, wastewater pump unit basins on floor or concrete base unless recessed installation is indicated. Make direct connections to drainage and vent piping.

I. Support piping so weight of piping is not supported by pumps.

3.4 CONNECTIONS

A. Piping installation requirements are specified in Division 22 Section "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to sewage pumps to allow service and maintenance.

C. Connect sanitary drainage and vent piping to pumps. Install discharge piping equal to or greater than size of pump discharge piping. Install vent piping equal to or greater than size of pump basin vent connection. Refer to Division 22 Section "Sanitary Waste and Vent Piping."
   1. Install flexible connectors adjacent to pumps in discharge piping.
   2. Install check and shutoff valves on discharge piping from each pump. Install unions on pumps having threaded pipe connections. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for sanitary waste piping.

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Verify bearing lubrication.

3. Disconnect couplings and check motors for proper direction of rotation.
4. Verify that each pump is free to rotate by hand. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
5. Verify that pump controls are correct for required application.

B. Start pumps without exceeding safe motor power:
1. Start motors.
2. Open discharge valves slowly.
3. Check general mechanical operation of pumps and motors.

C. Test and adjust controls and safeties.

D. Remove and replace damaged and malfunctioning components.
1. Pump Controls: Set pump controls for automatic start, stop, and alarm operation as required for system application.
2. Set field-adjustable switches and circuit-breaker trip ranges as indicated, or if not indicated, for normal operation.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following storm drainage piping inside the building:
   1. Adjust list below to suit Project.
   2. Pipe, tube, and fittings.
   3. Special pipe fittings.
   4. Encasement for underground metal piping.
   5. Drain tile piping.

B. Related Sections include the following:
   1. Division 22 Section "Sump Pumps."

1.3 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:
   1. Storm Drainage Piping: 10-foot head of water Insert pressure.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.4 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. Shop Drawings:
   1. Retain subparagraph below if piping is required to withstand specific design loads and Architect either has delegated design responsibility to Contractor or wants to review structural data as another way to verify compliance with performance requirements. Professional engineer qualifications are specified in Division 01 Section "Quality Requirements."Division 1 Section "Quality Requirements."
   2. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.
   3. Retain subparagraph below if controlled-flow storm drainage system is retained.
   4. Controlled-Flow Storm Drainage System: Include calculations, plans, and details.

C. Field quality-control inspection and test reports.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.3 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
   1. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
      a. Manufacturers:
         1) ANACO.
         2) Fernco, Inc.
         3) Ideal Div.; Stant Corp.
         4) Mission Rubber Co.
         5) Tyler Pipe; Soil Pipe Div.

2.4 SPECIAL PIPE FITTINGS

A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.
   1. Manufacturers:
      a. Dallas Specialty and Mfg. Co.
      b. Fernco, Inc.
      c. Logan Clay Products Company (The).
      d. Mission Rubber Co.
      e. NDS, Inc.
      f. Plastic Oddities, Inc.
   2. Sleeve Materials:
      a. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
      b. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

B. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
   1. Manufacturers:
      a. Cascade Waterworks Mfg. Co.
      b. Mission Rubber Co.

C. Expansion Joints: Two or three-piece, ductile-iron assembly consisting of telescoping sleeve(s) with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
   1. Manufacturers:
      a. EBAA Iron Sales, Inc.
      b. Romac Industries, Inc.

D. Wall-Penetration Fittings: Compound, ductile-iron coupling fitting with sleeve and flexing sections for up to 20-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
   1. Manufacturers:
      a. SIGMA Corp.

2.5 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Description: ASTM A 674 or AWWA C105, high-density, cross-laminated PE film of 0.004-inch or LLDPE film of 0.008-inch minimum thickness.

B. Form: Sheet or tube.

C. Color: Black or natural.

2.6 DRAINTILE PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, with perforations on one half of pipe. Provide with fabric mesh over outside of piping.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground storm drainage piping NPS 3 and larger shall be the following:
   1. Hubless cast-iron soil pipe and fittings; standard, and heavy-duty shielded, stainless-steel couplings; and coupled joints.
   2. Dissimilar Pipe-Material Couplings: Shielded or unshielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

C. Underground storm drainage piping NPS 4 and larger shall be the following:
   1. Hubless cast-iron soil pipe and fittings; standard, and heavy-duty shielded, stainless-steel couplings; and coupled joints.
   2. Dissimilar Pipe-Material Couplings: Shielded or unshielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

3.3 PIPING INSTALLATION

A. Storm sewer piping outside the building is specified in Division 33 Section "Storm Utility Drainage Piping."Division 2 Section "Storm Drainage." Edit first paragraph below to suit Project.

B. Storm sewer and drainage piping outside the building are specified in Division 33 Section "Storm Utility Drainage Piping."

C. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."

D. Retain first paragraph below if piping is required to withstand specific design loads.

E. Install seismic restraints on piping. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

F. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Division 22 Section "Storm Drainage Piping Specialties."

G. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.

H. Retain paragraph below if steel, force-main piping is required.

I. Install underground, steel, force-main piping. Install encasement on piping according to ASTM A 674 or AWWA C105.

J. Retain paragraph and subparagraph below if ductile-iron, force-main piping is required.

K. Retain one of first two paragraphs below for pipe.

L. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

M. Install wall-penetration fitting system at each service pipe penetration through foundation wall. Make installation watertight.

N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
   1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

O. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

P. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

Q. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:
   1. Edit two subparagraphs below as required by authorities having jurisdiction.
   2. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
   3. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

R. Install force mains at elevations indicated.

S. Install engineered controlled-flow storm drainage piping in locations indicated.

T. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

U. Install ABS storm drainage piping according to ASTM D 2661.

V. Install PVC storm drainage piping according to ASTM D 2665.

W. Install underground ABS and PVC storm drainage piping according to ASTM D 2321.

X. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Hubless Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

3.5 HANGER AND SUPPORT INSTALLATION

A. See division 22 specification, “HANGERS and SUPPORTS FOR PLUMBING PIPING and EQUIPMENT” for information on hanger support installation.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

D. Connect force-main piping to the following:
   1. Storm Sewer: To exterior force main or storm manhole.

3.7 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Test Procedure: Test storm drainage piping**,** on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

3.8 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION

STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following storm drainage piping specialties:
   1. Backwater valves.
   2. Cleanouts.
   3. Trench drains.
   4. Channel drainage systems.
   5. Catch basins.
   6. Through-penetration firestop assemblies.
   7. Roof drains.
   8. Miscellaneous storm drainage piping specialties.
   9. Flashing materials.

B. Related Sections include the following:
   1. Division 22 Section "Sanitary Waste Piping Specialties" for backwater valves, floor drains, trench drains and channel drainage systems connected to sanitary sewer, air admittance valves, FOG disposal systems, grease interceptors and removal devices, oil interceptors, and solid interceptors.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

1.5 COORDINATION

A. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Exposed Metal Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. MIFAB, Inc.
      b. Watts Drainage Products Inc.
      c. Zurn Plumbing Products Group; Specification Drainage Operation.
   2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
   3. Size: Same as connected drainage piping
   4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
   5. Closure: Countersunk or raised-head, brass plug.
   6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
   7. Retain last two subparagraphs above for ASME A112.36.2M cleanouts or subparagraph below for ASME A112.3.1, stainless-steel cleanouts.
   8. Closure: Stainless-steel plug with seal.

B. Metal Floor Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Josam Company; Josam Div.
      b. Watts Drainage Products Inc.
      c. Zurn Plumbing Products Group.
   2. Standard: ASME A112.36.2M for adjustable cleanout.
   3. Size: Same as connected branch.
   4. Type: Adjustable housing.
   5. Body or Ferrule: Cast iron.

6. Clamping Device: Required.
7. Outlet Connection: Threaded.
8. Closure: Brass plug with straight threads.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Coordinate with architect.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
14. Standard: ASME A112.3.1.
15. Size: Same as connected branch.
16. Housing: Stainless steel.
17. Closure: Stainless steel with seal.
18. Riser: Stainless-steel drainage pipe fitting to cleanout.

C. Cast-Iron Wall Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. MIFAB, Inc.
b. Watts Drainage Products Inc.
c. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Option for drilled-and-threaded plug in first subparagraph below is for a screw for a wall cover plate.
6. Closure: Drilled-and-threaded brass cast-iron plug.
7. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
8. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
9. Wall Access: Round or Square, stainless-steel wall-installation frame and cover as required by architect.

2.2 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ProSet Systems Inc.
b. Unique Fire Stop Products
c. Convenience Products
2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
3. Size: Same as connected pipe.
4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
5. Fitting in subparagraph below is for use with plastic stacks.
6. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
7. Special Coating: Corrosion resistant on interior of fittings.

2.3 ROOF DRAINS

A. Metal Roof Drains:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. MIFAB, Inc.
b. Watts Drainage Products Inc.
c. Zurn Plumbing Products Group.
2. Standard: ASME A112.21.2M.
3. Body Material: Cast iron.
4. Dimensions of Body: As noted on Plumbing Plans.
5. Combination Flashing Ring and Gravel Stop: Required.
6. Outlet: Bottom, unless noted uniquely on Plumbing Plans.
7. Dome Material: Cast iron.
8. Extension Collars: Required.
9. Underdeck Clamp: Required.

2.4 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Conductor Nozzles:
   1. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.
   2. Size: Same as connected conductor.

2.5 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft..

B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.

C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.

D. Fasteners: Metal compatible with material and substrate being fastened.

E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

F. Solder: ASTM B 32, lead-free alloy.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
   1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate at each change in direction of piping greater than 45 degrees.
   3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
   4. Locate at base of each vertical soil and waste stack.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Retain one of first two paragraphs below.

F. Assemble FRP channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.

G. Retain one of first two paragraphs below.

H. Install through-penetration firestop assemblies in plastic conductors and stacks at floor penetrations.

I. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 07.
   1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
   2. Position roof drains for easy access and maintenance.

J. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

K. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

L. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.

M. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
   1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
   2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
   1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
   2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
   3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Coordinate paragraph below with Division 07 Section "Sheet Metal Flashing and Trim."Division 7 Section "Sheet Metal Flashing and Trim."

F. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SUMP PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following sump pumps and accessories, inside the building, for building storm drainage systems:
   1. Sump pump basins.

B. Related Sections include the following:
   1. Division 22 Section "Sanitary Sewerage Pumps" for application in sanitary drainage systems.

1.3 SUBMITTALS

A. Product Data: For each type and size of sump pump specified, include certified performance curves with operating points plotted on curves, and rated capacities of selected models, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For each sump pump to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of sump pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

1.6 WARRANTY

A. This warrant shall be in addition to, and not limitation of, other rights the owner may have against the contractor under the contract documents.

B. Warranty period is one year after substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

1. Weil
2. Hydromatic
3. ABS
4. Zoeller

2.2 WET-PIT-MOUNTED, VERTICAL SUMP PUMPS

A. Available Manufacturers:
   1. Weil, Metropolitan, ABS.

B. Description: Factory-assembled and -tested, single-stage, centrifugal, end-suction sump pumps complying with UL 778. Vertical, separately coupled, suspended pumps complying with HI 1.1-1.2 and HI 1.3 for wet-pit-volute sump pumps
   1. Pump Arrangement: Duplex.
   2. Casing: Cast iron, with screened inlet and threaded connection for NPS 2 and smaller and flanged connection for NPS 2-1/2 and larger discharge piping.

3. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced nonclog design; overhung, single suction, keyed and secured to shaft.
4. Pump Shaft and Sleeve Bearings: Stainless-steel shaft with bronze sleeve bearings. Include oil-lubricated, intermediate sleeve bearings at 48-inch maximum intervals if basin depth is more than 48 inches, and grease-lubricated, ball-type thrust bearings.
5. Pump and Motor Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.

C. Pump Discharge Piping: Manufacturer's standard galvanized-steel or bronze pipe.

E. Basin Cover: Cast iron or steel with bituminous coating and strong enough to support pumps, motors, and controls.

F. Cover Shaft Seal: Stuffing box, with graphite-impregnated braided-yarn rings and bronze packing gland.

G. Motor: Single speed; grease-lubricated ball bearings. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment" with built-in thermal-overload protection appropriate for motor size and duty.
1. Mounting: On vertical, cast-iron pedestal.

H. Controls in paragraph below are rod-and-float type. Micropressure and mercury-float switches are also available. Retain last option for duplex pump units.

I. Controls: NEMA 250, Type 1 enclosure, pedestal-mounted float switches; with floats, float rods, and rod buttons.
1. Feature in subparagraph below is required for controlling turbulence in deep basins with rod-and-float-type controls.
2. Float Guide: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches.
3. Verify availability of alarm types with manufacturer.
4. High-Water Alarm: Cover-mounted, mechanical-float-switch alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

J. Capacity and Characteristics:
1. See Sump Pump Schedule on plumbing plans for general pump characteristics and electrical capacities.

2.3 SUMP PUMP BASINS

A. Description: Factory fabricated basin with sump, pipe connections, and separate cover.

B. Sump: Fabricate watertight, with sidewall openings for pipe connections.
1. Material: Fiberglass.
2. Reinforcement: Mounting plates for pumps, fittings, and accessories.
3. Anchor Flange: Same material as or compatible with sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.

C. Cover: Fabricate with openings having gaskets, seals, and bushings, for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
1. Material: Steel with epoxy-coating.
2. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

D. Capacity and Characteristics:
1. Discharge: 3”
2. See Sump Pump Schedule on plumbing plans for general pump characteristics and sizes.

2.4 FLEXIBLE CONNECTORS

A. Description: 125-psig minimum working-pressure rating and ends matching pump connection:
1. Stainless-Steel Flexible Connectors: Corrugated, stainless-steel inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to tubing.

2.5 BUILDING AUTOMATION SYSTEM INTERFACE

A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:
1. On-off status of each pump.

2. Alarm status.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of plumbing piping to verify actual locations of storm drainage piping connections before sump pump installation.

3.2 SUMP PUMP INSTALLATION

A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

B. Install sump pumps according to applicable requirements in HI 1.4.

C. Install packaged, submersible, drainage pump unit basins on floor of basin and arrange to provide access for maintenance including removal of motors, impellers, couplings, and accessories. Install.

E. Install sump pump basins and connect to drainage piping. Brace interior of basins according to manufacturer's written instructions to prevent distortion or collapse during concrete placement. Set basin cover and fasten to basin top flange. Install cover so top surface is flush with finished floor.

F. Construct sump pump pits and connect to drainage piping. Set pit curb frame recessed in and anchored to concrete. Fasten pit cover to pit curb flange. Install cover so top surface is flush with finished floor.

G. Pump basin shall be 36” x 84” deep fiberglass with a duplex steel cover including pump access plates with discharge flange and cable slot, vent flange and inspection opening. Contractor shall furnish check and gate valves on discharge line.

H. Support piping so weight of piping is not supported by pumps.

3.3 CONNECTIONS

A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

B. Piping installation requirements are specified in Division 22 Section "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Install piping adjacent to sump pumps to allow service and maintenance.

D. Connect storm drainage piping to pumps. Install discharge piping equal to or greater than size of pump discharge piping. Refer to Division 22 Section "Facility Storm Drainage Piping."
   1. Install flexible connectors adjacent to pumps in discharge piping.
   2. Install check and shutoff valves on discharge piping from each pump. Install unions on pumps having threaded pipe connections. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for drainage piping.

E. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Verify bearing lubrication.
   3. Disconnect couplings and check motors for proper direction of rotation.
   4. Verify that each pump is free to rotate by hand. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   5. Verify that pump controls are correct for required application.

B. Start pumps without exceeding safe motor power:
   1. Start motors.
   2. Open discharge valves slowly.
   3. Check general mechanical operation of pumps and motors.

C. Test and adjust controls and safeties.

D. Remove and replace damaged and malfunctioning components.
   1. Pump Controls: Set pump controls for automatic start, stop, and alarm operation as required for system application.
   2. Set field-adjustable switches and circuit-breaker trip ranges as indicated, or if not indicated, for normal operation.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

FUEL-FIRED DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following fuel-fired water heaters:
   1. Commercial, high-efficiency, power vent gas water heaters.
   2. Compression tanks.
   3. Water heater accessories.

1.3 SUBMITTALS

A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Product Certificates: For each type of commercial water heater, signed by product manufacturer.

D. Source quality-control test reports.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For water heaters to include in emergency, operation, and maintenance manuals.

G. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of water heaters through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of water heaters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASME Compliance:
   1. Where ASME-code construction is indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.

E. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

1.5 COORDINATION

A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired water heaters that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures including storage tank and supports.
      b. Faulty operation of controls.
      c. Deterioration of metals, metal finishes, and other materials beyond normal use.
   2. Warranty Period(s): From date of Substantial Completion:
      a. Provide manufacture’s standard warranty for materials and labor, commencing on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 COMMERCIAL, GAS WATER HEATERS

A. Commercial, High-Efficiency, Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.
   1. Manufacturers:
      a. Lochinvar Corporation.
      b. Smith, A. O. Water Products Company.
      c. State Industries, Inc.
   2. Verify combustion efficiency of model selected in first subparagraph below.
   3. Description: Manufacturer's proprietary design to provide at least percentage combustion efficiency, listed on plumbing water heater schedule, at optimum operating conditions. Following features and attributes may be modified or omitted if water heater otherwise complies with requirements for performance.
   4. Storage-Tank Construction: ASME-code steel with 150-psig minimum working-pressure rating.
      a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
         1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
         2) NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
      b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   5. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for high-efficiency water heaters and for natural-gas fuel.
   6. Temperature Control: Adjustable thermostat.
   7. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
   8. Energy Management System Interface: Normally closed dry contacts for enabling and disabling water heater.
   9. Capacity and Characteristics:
      a. See water heater schedule for capacity and characteristics.

2.3 COMPRESSION TANKS

A. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
   1. Manufacturers:
      a. Amtrol
      b. Smith, A. O.; Aqua-Air Div.
      c. State Industries, Inc.
      d. Watts Regulator Co.
   2. Construction:
      a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
      b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
      c. Air-Charging Valve: Factory installed.
   3. Capacity and Characteristics:
      a. Install per manufacture’s recommendations.

2.4 WATER HEATER ACCESSORIES

A. Gas Shutoff Valves: ANSI Z21.15/CGA 9.1, manually operated. Furnish for installation in piping.

B. Gas Pressure Regulators: ANSI Z21.18, appliance type. Include pressure rating, capacity, and pressure differential required between gas supply and water heater.

C. Gas Automatic Valves: ANSI Z21.21, appliance, electrically operated, on-off automatic valve.

D. Combination Temperature and Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select each relief valve with sensing element that extends into storage tank.
   1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.

E. Pressure Relief Valves: Include pressure setting less than working-pressure rating of water heater.
   1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.

F. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

2.5 SOURCE QUALITY CONTROL

A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Retain first paragraph below if tank testing by manufacturer is required. Retain option if testing of only commercial water heater tanks is required.

C. Hydrostatically test commercial water heater storage tanks before shipment to minimum of one and one-half times pressure rating.

D. Prepare test reports.

PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

A. Install commercial water heaters on concrete bases.
   1. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.
   2. Coordinate sizes and locations of concrete bases. Verify structural requirements with structural engineer.
   3. Concrete base construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

C. Install gas water heaters according to NFPA 54.

D. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.

E. Install gas pressure regulators on gas supplies to gas water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.

F. Install automatic gas valves on gas supplies to gas water heaters, if required for operation of safety control.

G. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

H. Install combination temperature and pressure relief valves in water piping for water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

I. Install thermometer on outlet piping of water heaters. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

J. Install pressure gage(s) on inlet and outlet piping of commercial, fuel-fired water heater piping. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.

K. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve and thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves and to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

L. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.

M. Fill water heaters with water.

N. Retain paragraph below only if required.

O. Charge compression tanks with air.

P. Provide concrete pad for water heaters, install according to Division 22 Specifications, Common Work Results for Plumbing.

3.2 CONNECTIONS

A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

B. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

C. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Retain first paragraph below to require a factory-authorized service representative to perform, or assist Contractor with, field inspections, tests, and adjustments. Retain one of two options to suit Project; delete both to require only an inspection before field testing.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

C. Perform the following field tests and inspections and prepare test reports:
1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial water heaters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:
   1. Faucets for lavatories and sinks.
   2. Flushometers.
   3. Toilet seats.
   4. Protective shielding guards.
   5. Fixture supports.
   6. Water closets.
   7. Urinals.
   8. Lavatories.
   9. Kitchen sinks.
   10. Service sinks.

B. Related Sections include the following:
   1. Division 22 Section "Domestic Water Piping Specialities" for backflow preventers, floor drains, and specialty fixtures not included in this Section.
   2. Division 22 Section "Drinking Fountains and Water Coolers."

1.3 DEFINITIONS

A. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

1.4 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

D. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
   1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
   1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
   2. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
   3. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
   4. Stainless-Steel Residential Sinks: ASME A112.19.3.
   5. Vitreous-China Fixtures: ASME A112.19.2M.
   6. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.
   7. Water-Closet, Flushometer Tank Trim: ASSE 1037.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
   1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
   2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
   3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
   4. Faucets: ASME A112.18.1.
   5. Hose-Connection Vacuum Breakers: ASSE 1011.
   6. Hose-Coupling Threads: ASME B1.20.7.
   7. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
   8. NSF Potable-Water Materials: NSF 61.
   9. Pipe Threads: ASME B1.20.1.
   10. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
   11. Supply Fittings: ASME A112.18.1.
   12. Brass Waste Fittings: ASME A112.18.2.

I. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
   1. Atmospheric Vacuum Breakers: ASSE 1001.
   2. Brass and Copper Supplies: ASME A112.18.1.
   3. Dishwasher Air-Gap Fittings: ASSE 1021.
   4. Manual-Operation Flushometers: ASSE 1037.
   5. Plastic Tubular Fittings: ASTM F 409.
   6. Brass Waste Fittings: ASME A112.18.2.
   7. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.

J. Comply with the following applicable standards and other requirements specified for miscellaneous components:
   1. Flexible Water Connectors: ASME A112.18.6.
   2. Floor Drains: ASME A112.6.3.
   3. Grab Bars: ASTM F 446.
   4. Hose-Coupling Threads: ASME B1.20.7.
   5. Pipe Threads: ASME B1.20.1.
   6. Plastic Toilet Seats: ANSI Z124.5.
   7. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 WARRANTY

1. Provide manufacture’s standard 1-year warranty for materials and labor, commencing on date of preliminary acceptance.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
   2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.
   3. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than 12 of each type.
   4. Provide hinged-top wood or metal box, or individual metal boxes, with separate compartments for each type and size of extra materials listed above.
   5. Flushometer Tank, Repair Kits: Equal to 5 percent of amount of each type installed, but no fewer than 2 of each type.
   6. Toilet Seats: Equal to 5 percent of amount of each type installed.

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

A. Lavatory Faucets:
1. Manufacturers: Subject to compliance with requirements, provide products listed below:
a. Toto
b. Kohler
c. American Standard
2. Description: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
a. See plumbing fixture schedule for additional information and design criteria.

2.2 SINK FAUCETS

A. Sink Faucets:
1. Manufacturers: Subject to compliance with requirements, provide products listed in the facility standard list of preferred manufactures:
a. Chicago Faucet
2. Description: Kitchen faucet, three-hole fixture. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
a. See plumbing fixture schedule for additional information and design criteria.

2.3 FLUSHOMETERS

A. Flushometers:
1. Manufacturers: Subject to compliance with requirements, provide products listed in the facility standard list of preferred manufactures:
a. Sloan
b. Zurn
2. Description: Flushometer for urinal and water-closet-type fixture. Include brass body with corrosion-resistant internal components, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts.
a. Internal Design: piston operation.
b. Style: Exposed.
c. See plumbing plans for additional information and design criteria.

2.4 TOILET SEATS

A. Toilet Seats:
1. Manufacturers: Subject to compliance with requirements, provide products listed in the facility standards list of preferred manufactures:
2. Description: Toilet seat for water-closet-type fixture.
a. Material: Molded, solid plastic with antimicrobial agent.
b. Configuration: Open front without cover.
c. Size: Elongated.
d. Class: Standard commercial
e. Color: White.

2.5 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:
1. Description: Manufactured plastic wraps for covering plumbing fixture hot-water supply hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

2.6 FIXTURE SUPPORTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. MIFAB Manufacturing Inc.
2. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
3. Zurn Plumbing Products Group; Specification Drainage Operation.

B. Water-Closet Supports:

1. Description: Combination carrier designed for accessible and standard mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

C. Urinal Supports:
1. Description: Type II, urinal carrier with hanger and bearing plates for wall-mounting, urinal-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

D. Lavatory Supports:
1. Description: Type III, lavatory carrier with hanger plate and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

E. Sink Supports:
1. Description: Type III, sink carrier with hanger plate and exposed arms for sink-type fixture. Include steel uprights with feet.

2.7 WATER CLOSETS

A. Water Closets:
1. Manufacturers: Subject to compliance with requirements, provide products listed below:
a. Toto
b. Kohler
c. American Standard
2. Description Accessible and standard, wall-mounting, back-outlet, vitreous-china fixture designed for flushometer valve operation.
a. See plumbing plans for additional information and design criteria.

2.8 URINALS

A. Urinals:
1. Manufacturers: Subject to compliance with requirements, provide products listed below:
a. Toto
b. Kohler
c. American Standard
2. Description: Accessible and standard, wall-mounting, back-outlet, vitreous-china fixture designed for flushometer valve operation.
a. See plumbing plans for additional information and design criteria.

2.9 LAVATORIES

A. Lavatories:
1. Manufacturers: Subject to compliance with requirements, provide products listed below:
a. Toto
b. Kohler
c. American Standard
2. Description: Accessible and standard, wall-mounting, vitreous-china fixture.
a. See plumbing fixture schedule for additional information and design criteria.

2.10 SERVICE SINKS

A. Service Sinks:
1. Manufacturers: Subject to compliance with requirements, provide products listed in the facility standard of preferred manufactures:

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall-mounting fixtures with tubular waste piping attached to supports.

F. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.

G. Install counter-mounting fixtures in and attached to casework.

H. Install fixtures level and plumb according to roughing-in drawings.

I. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

K. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

L. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

M. Install toilet seats on water closets.

N. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

O. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

P. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

Q. Install traps on fixture outlets.
1. Exception: Omit trap on fixtures with integral traps.
2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

R. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."

S. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

C. Replace washers and seals of leaking and dripping faucets and stops.

D. Install fresh batteries in sensor-operated mechanisms.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
   1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
   2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

DRINKING FOUNTAINS AND WATER COOLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following water coolers and related components:
   1. Water-station water coolers.
   2. Fixture supports.

1.3 DEFINITIONS

A. Accessible Water Cooler: Fixture that can be approached and used by people with disabilities.

B. Cast Polymer: Dense, cast-filled-polymer plastic.

C. Fitting: Device that controls flow of water into or out of fixture.

D. Fixture: Drinking fountain or water cooler unless one is specifically indicated.

E. Water Cooler: Electrically powered fixture for generating and delivering cooled drinking water.

1.4 SUBMITTALS

A. Product Data: For each fixture indicated. Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For fixtures to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for fixtures for people with disabilities.

C. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

D. ARI Standard: Comply with ARI's "Directory of Certified Drinking Water Coolers" for style classifications.

E. ARI Standard: Comply with ARI 1010, "Self-Contained, Mechanically Refrigerated Drinking-Water Coolers," for water coolers and with ARI's "Directory of Certified Drinking Water Coolers" for type and style classifications.

F. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant, unless otherwise indicated.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS

A. Water Coolers:
   1. Manufacturers: Subject to compliance with requirements, provide products listed in the facility standard list of preferred manufactures:
      a. Oasis Corporation.

   2. Description: ARI 1010, Type PB, pressure with bubbler, water cooler.
      a. Sports bottle filler with independent manual activation; lower unit with front and side push pads to activate the manual flow of water for the cooler.
      b. Bubbler: One, with adjustable stream regulator, located on deck.

c. Control: Push button.
d. Supply: NPS 3/8 with ball, gate, or globe valve.
e. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
f. Drain: Grid with NPS 1-1/4 minimum horizontal waste and trap complying with ASME A112.18.2.
g. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
1) See plumbing fixture schedule for electric capacity and characteristics.

2.2 FIXTURE SUPPORTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. MIFAB Manufacturing, Inc.
2. Watts Drainage Products
3. Zurn Plumbing Products

B. Description: ASME A112.6.1M, water cooler carriers. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.
1. Type I: Hanger-type carrier with two vertical uprights.
2. Type II: Bilevel, hanger-type carrier with three vertical uprights.
3. Supports for Accessible Fixtures: Include rectangular, vertical, steel uprights instead of steel pipe uprights.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before fixture installation. Verify that sizes and locations of piping and types of supports match those indicated.

B. Examine walls and floors for suitable conditions where fixtures are to be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Use carrier off-floor supports for wall-mounting fixtures, unless otherwise indicated.

B. Use mounting frames for recessed water coolers, unless otherwise indicated.

C. Set freestanding and pedestal drinking fountains on floor.

D. Set remote water coolers on floor, unless otherwise indicated.

E. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.

3.3 INSTALLATION

A. Install off-floor supports affixed to building substrate and attach wall-mounting fixtures, unless otherwise indicated.

B. Install mounting frames affixed to building construction and attach recessed water coolers to mounting frames, unless otherwise indicated.

C. Install fixtures level and plumb. For fixtures indicated for children, install at height required by authorities having jurisdiction.

D. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

E. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

F. Install pipe escutcheons at wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding pipe fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."

G. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.
   1. Remove and replace malfunctioning units and retest as specified above.
   2. Report test results in writing.

3.6 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust water cooler temperature settings.

3.7 CLEANING

A. After completing fixture installation, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

END OF SECTION

GENERAL PROVISIONS FOR HVAC WORK

PART 1 - GENERAL

1.1 SUMMARY

A. The work under Division 23 "Heating, Ventilating, and Air Conditioning (HVAC)" shall include all labor, services, materials and equipment and performance of all work required for the installation of all mechanical work as shown on the Drawings and herein specified in the following Sections.

B. Should there be any discrepancies or a question of intent, refer the matter to the Architect/Engineer for decision before ordering any equipment or materials or before starting any related work.

C. Where work connects to that of another trade, or to piping or equipment in place, take measurements in the field to make connecting work come true and line up with the item being connected.

D. Where work specified under other Divisions of the Specifications connects to equipment which is a part of Division 23, provide proper connection(s) to such equipment.

E. Minor items and accessories or devices reasonably inferable as necessary, to the complete and proper installation and operation of any system, shall be provided by the Trade Contractor for such system whether or not they are specifically called for by the Specifications or Drawings.

F. The Drawings and Specifications are to be taken together. Work specified and not shown or work shown and not specified shall be performed or furnished as though mentioned in both Specifications and Drawings. If there is a discrepancy between the Drawings and Specifications as to the quantity or quality to be provided, the greater quantity or the better quality shall be provided.

1.2 DEFINITIONS

A. "Piping" includes, in addition to pipe, all fittings, valves, hangers, and other supports and accessories related to such piping.

B. "Ductwork" includes, in addition to ducts, all fittings, transitions, dampers, hangers and other supports and accessories related to such ductwork.

C. "Concealed" means hidden from sight in chases, furred spaces, shafts, hung ceilings, embedded in construction, in crawl spaces or buried.

D. "Exposed" means not installed underground or "concealed" as defined above.

E. "Invert Elevations" means the elevation of the inside bottom of pipe or duct.

F. "HVAC Work" is all of the work in Division 23.

1.3 QUALITY ASSURANCE

A. Each major component of equipment to have the manufacturer's name, address, model number and rating on a plate securely affixed in a conspicuous place.

B. Code Ratings, labels or other data which are die-stamped or otherwise affixed to the surface of the equipment shall be in visible location.

C. All equipment provided under Division 23 to perform with the least possible noise and vibration consistent with its duty. Quietness of operation of all equipment is a requirement. Any equipment, as determined by the Owner’s Representative or Architect/Engineer to be producing objectionable noise or transmitting noise or vibration to the building to be repaired or removed and replaced.

D. All workmanship shall be first class in every respect and shall be performed only by skilled mechanics.

E. Shutdown and Notifications:
   1. It is imperative that service interruptions on the various existing utilities be held to an absolute minimum. Wherever possible provide suitable temporary services or connections, where continuity of service for essential systems can be maintained by this means. It will be the Owner's final prerogative to decide which systems are to be considered as essential, and to establish the maximum allowable shutdown time, if any, for each system.
   2. Owner will require not less than 72 hours advance notice, in writing, that an interruption of service in any system is desired. Such notice shall identify the system or systems involved, and shall be submitted in duplicate, one copy of which will be signed and returned by the Owner's authorized representative stating whether the requested shutdown will be permitted or not.

F. Existing Utilities:

1. Location of utilities as shown on the drawings has been determined from the best available information and is given for convenience; however, Owner does not assume responsibility in the event that during construction, utilities other than those shown may be encountered, and that the actual location of those which are shown may be different from the location as shown on the plans.
2. Assume responsibility for interference with or damage to any existing utilities, and repair or replace same with the least possible delay.

G. Notify Architect of broken or open pipes discovered during construction.

H. Layout and establish the lines and levels necessary for work.

I. The following Standards shall be used where referenced by the following abbreviations:
1. AABC: Associated Air Balance Council
2. ADC: Air Diffusion Council
3. AGA: American Gas Association
4. AIA: American Institute of Architects
5. AMCA: Air Moving and Conditioning Association
6. ANSI: American National Standards Institute
7. ARI: Air Conditioning and Refrigeration Institute
8. ASE: Association of Safety Engineers
9. ASHRAE: American Society of Heating, Refrigeration and Air Conditioning Engineers
10. ASME: American Society of Mechanical Engineers
11. ASPE: American Society of Plumbing Engineers
12. ASTM: American Society of Testing and Materials
13. AWPB: American Wood Preserves Bureau
14. AWS: American Welding Society
15. AWWA: American Water Works Association
16. CSA: Canadian Standards Association
17. CISPI: Cast Iron Soil Pipe Institute
18. EIA: Electronic Industries Association
19. EPA: Environmental Protection Agency
20. FDA: Food and Drug Administration
21. FM: Factory Mutual Insurance Association
22. HIS: Hydraulic Institute Standards
23. IRI: Industrial Risk Insurers
24. IBR: Institute of Boiler and Radiator Manufacturers
25. IEEE: Institute of Electrical and Electronics Engineers
26. MCAA: Mechanical Contractors' Association of America
27. NIST: National Institute of Standards and Testing
28. NEBB: National Environmental Balancing Bureau
29. NEC: National Electric Code
30. NECA: National Electric Contractors Association
31. NEMA: National Electrical Manufacturers Association
32. NFPA: National Fire Protection Association
33. NSC: National Safety Council
34. NSF: National Sanitation Foundation
35. OSHA: Occupational Safety and Health Administration
36. SAE: Society of Automotive Engineers
37. SBI: Steel Boiler Institute Industry
38. SMACNA: Sheet Metal and Air Conditioning Contractors National Association
39. TIMA: Thermal Insulation Manufacturers Association
40. UL: Underwriters' Laboratories
41. USDA: United States Department of Agriculture

J. Project Certification:
1. Each trade shall submit a project certification, guaranteeing that this project was constructed and will operate in accordance with the performance requirements of the Drawings and Specifications. This certification shall be signed by a principal of the firm and shall be delivered to the Architect/Engineer prior to final payment.

K. Drawings:

1. The Drawings are essentially diagrammatic in nature and show general arrangement of the equipment, piping, ductwork, accessories, etc. Because of the small scale of the Drawings, it is not possible to show each offsets, fittings, and accessories, which may be required. Carefully investigate the structural conditions, Architectural Drawings, Equipment Drawings, and the finished conditions of the work and arrange such work accordingly, furnish any fittings, pipe accessories that may be required to meet such conditions.
2. Any changes from the plans necessary to make the work conform to building as constructed and to fit work of other trades, or to conform to rules of the governing authorities and regulations, shall be met without extra cost to the Owner.
3. The layout of the piping, ductwork, equipment, etc., as shown on the Drawings shall be checked and exact locations shall be determined by the dimensions of equipment approved and Contractor shall obtain the Architect's approval for revised layout before the apparatus is installed. Consult the Architectural, Structural, and Equipment Drawings for the dimensions, locations of partitions, locations and sizes of structural supports, foundations, etc.
4. Refer to the Architectural Plans for details and large scale Drawings and to approved Shop Drawing of equipment furnished under other Contracts or Sections of the Specifications for exact location of service connections. The equipment Shop Drawings will be furnished to the Contractor before roughing in. Contractor shall not install any piping or ductwork for said equipment until they have received approved Coordination Drawings for same.

L. Minor Deviations:
1. The dimensions of equipment hereinafter specified or indicated on the Drawings are intended to establish the outlines and characteristics of such equipment in general. Minor deviations in dimensions will be permitted to allow the manufacturers specified to bid on their nearest stock equipment, provided the specified ratings are met or exceeded.
2. Where manufacturers' catalog numbers or types are mentioned in the Specifications or indicated on the Drawings, they are intended to be used as a guide only and shall not be interpreted as taking precedence over the basic rating and duty specified. In all cases, manufacturers shall verify the duty specified with particular characteristics of the equipment they intend to offer for approval and shall also pay the additional charges as may be required under other Divisions.

M. Interferences:
1. Before making any installation, the work of the trades must be coordinated and the necessary changes shall be made to avoid interferences or improper effect on work to be performed by any other Section. In the event that interferences develop, the Architect's decision will be final and no additional compensation will be allowed for moving of misplaced piping, ducts, conduit and/or equipment.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Unless otherwise specified, all material and equipment incorporated in the work under the contract shall be new.

B. Material and equipment specified by one or more manufacturer's name, trade name and/or model number does not limit a bidder from bidding on other equipment providing the procedure set forth in the Conditions of the Contract and hereinafter specified is followed.

C. The various mechanical systems have been engineered and designed on equipment name and catalog numbers specified or designated on the Drawings.

D. A Contractor who intends to furnish equipment listed as approved equal shall proceed as follows:
1. Obtain Architect/Engineer's approval of said equipment.
2. Be fully responsible for said equipment.
3. Include in the Base Bid, all cost for any changes that may be required in his work and/or work of other trades for the proper installation and functioning of said equipment.

PART 3 - EXECUTION

3.1 ALTERATIONS IN PRESENT BUILDING AND SITE

A. Take particular note of the revisions and alterations of existing services, utilities, etc., due to the new construction as indicated on the Drawings and/or as required by alterations to the existing building.

1. Where necessary, reroute piping, ducts, etc. from within walls, floors, ceilings, etc. being removed. The Trade Contractor involved with the interrupted service shall be responsible for accomplishing the required work whether shown on the Drawings or not.
2. Cap all abandoned or terminated piping, etc. below floor, behind wall surface, above ceiling, etc. as required to be completely concealed after new work is complete.
3. In general, mechanical remodeling work is shown on the Mechanical Drawings but carefully study all Drawings for all contracts for "demolition" and "remodeling" work in the existing buildings and field check to verify locations where such work is being done to determine the exact extent of work required. No extra will be allowed for additional work required because of demolition or remodeling whether or not work is specifically noted, itemized or shown on the Drawings.
4. Maintaining of Present Services: Maintain all services in the existing building. This shall include all temporary or permanent piping connections, etc., required to provide and maintain services to the present buildings and the equipment served. In the case of change over piping and ductwork or where new service connections are to be made to existing services and service interruptions can in no way be avoided, the service interruptions shall be with the minimum of inconvenience to the School. If the Owner’s Representative directs that such work be performed during premium time hours then the Contractor shall be reimbursed for the premium time portion of the direct labor cost of the workmen actually performing the work. All costs (except for premium time portion of labor costs) incurred in order to comply with the foregoing shall be included in the Contractor's original bid for the work and without additional costs to the Board.
5. Remove or reroute, as required, all services at existing buildings to be demolished.

3.2 DISPOSITION OF REMOVED EQUIPMENT

A. Where existing materials or equipment are specified to be removed from service, the Trade Contractor shall take possession of same and remove them from the site promptly, except as specified below or unless otherwise noted on Drawings.

B. All salvageable material and equipment, including but not necessarily limited to, electrical fixtures, conduit, wiring, plumbing fixtures, heating units, piping, valves, etc., shall be removed and maintained in as good condition as possible and turned over to the owner. However, if the owner decides any such materials are of no value, then they shall become the property of the Contractor who shall remove such discarded work from the premises and dispose of same.

C. Existing equipment or systems, etc. which are specified to be replaced by new equipment, or systems, etc. shall not be removed from service until the new equipment, materials, systems, etc. have actually arrived at the project site.

3.3 INSTALLATION

A. Each Trade Contractor shall be responsible for all of his work fitting into place in a satisfactory and neat workmanlike manner acceptable to the Architect/Engineer.

B. Confer with other Trade Contractors regarding the location and size of pipes, equipment, fixtures, conduit, ducts, openings, switches, outlets, etc., in order that there may be no interference between the installation of the progress of the work of any Trade Contractor on the project. The Architectural Drawings shall take precedence over the Mechanical and Electrical Drawings.

C. The Mechanical Drawings are diagrammatic and shall be followed as closely as actual construction of the building and the work of other trade contractors will permit. All changes from Drawings necessary to make the work of each Contractor conform to the building construction and the work of other trade contractors shall be done at the appropriate Trade Contractor's expense.

D. Unless explicitly stated to the contrary, each Trade Contractor shall furnish and install each item of equipment or material hereinafter specified, complete with all necessary fittings, supports, trim, piping, insulation, etc., as required for a complete and operating installation.

E. All equipment and materials shall be installed according to the manufacturer's instructions unless otherwise specifically directed by the Trade Contract Documents. All piping, valves, connections, and other like items recommended by the manufacturer or required for proper operation shall be provided without additional cost to the owner.

F. All references to Contractors in Specifications and Drawings shall refer to the respective Trade Contractor performing that portion of the work.

G. In general, all piping, ductwork and similar items shall be installed concealed from view above the ceiling, in partitions, shafts, chases, unless otherwise indicated.

H. Locations of items not definitely fixed by dimensions are approximate only and exact locations necessary to secure the best conditions and results shall be determined at the site, subject to review.

I. Where pipes are in partitions, furred out spaces and chases, obtain information as to their exact location and size and install work so as to be entirely concealed in the allotted space. If conflicts arise making this impossible, obtain instructions from the Architect/Engineer before proceeding with the work.

J. Wherever two or more pipes are to be installed in parallel, or parallel to the piping of other trades, the piping shall be installed with sufficient space between pipes to allow for the proper application of pipe covering, painting and servicing.

K. Furnish advance information on locations and sizes of frames, boxes, sleeves and openings needed for the work, and also furnish information and shop drawings necessary to permit installation of other work without delay.

L. Where there is evidence that parts of the Mechanical Work will interfere with other work, assist in working out space conditions and/or the structure, make necessary adjustments to accommodate the work.

M. Mechanical Work installed before coordinating with other work so as to cause interference with other work shall be changed to correct such condition without additional cost to the Owner.

N. In no case shall any pipe, conduit, duct, or item of equipment be installed where it is supported on or suspended from another pipe, conduit, duct or item of equipment.

O. Where an item or task is specified to be provided "under this Section," it shall be understood that, that item or task is the responsibility of the trade responsible for that Section, but the work must be performed by qualified workmen of the appropriate trade.

P. Accessibility:
   1. Install Mechanical work to permit removal (without damage to other parts) of coils, heat exchangers, pumps, fan shafts and wheels, belt guards, sheaves and drives, and other parts requiring periodic replacement or maintenance.
   2. Arrange pipes, ducts, and equipment to permit ready access to valves, cocks, traps, starters, motors, dampers, control components, and to clear the openings of swinging and overhead doors and of access panels.
   3. Change dimensions of ductwork when required to meet job conditions but maintain the same equivalent cross-sectional area.
   4. Provide access panels in equipment, ducts, and like items for inspection of interiors and proper maintenance.

END OF SECTION

BASIC HVAC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:
1. Piping materials and installation instructions common to most piping systems.
2. Concrete base construction requirements.
3. Escutcheons.
4. Dielectric fittings.
5. Mechanical sleeve seals.
6. Equipment nameplate data requirements.
7. Nonshrink grout for equipment installations.
8. Field-fabricated metal and wood equipment supports.
9. Installation requirements common to equipment specification sections.
10. Mechanical demolition.
11. Cutting and patching.
12. Touchup painting and finishing.
13. Access Panels
14. Bearings
15. Drives
16. Flashings
17. Cleaning

B. Pipe and pipe fitting materials are specified in Division 22.

1.2 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants, but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for rubber materials:
1. BS: Acrylonitrile-butadiene-styrene plastic.
2. CPVC: Chlorinated polyvinyl chloride plastic.
3. CR: Chlorosulfonated polyethylene synthetic rubber.
4. EPDM: Ethylene-propylene-diene terpolymer rubber.
5. NBR: Acrylonitrile-butadiene rubber.
6. PE: Polyethylene plastic.
7. PVC: Polyvinyl chloride plastic.

1.3 SUBMITTALS

A. Refer to Division 01 Section “Submittal Procedures” for administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other miscellaneous submittals.

B. Product Data: For dielectric fittings, flexible connectors, mechanical sleeve seals, access panels and identification materials and devices.

C. Coordination Drawings: For access panel and door locations.

D. Coordination Drawings: Detail major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Show space

requirements for installation and access. Indicate if sequence and coordination of installations are important to efficient flow of the Work. Include the following:

1. Planned piping layout, including valve and specialty locations and valve-stem movement.
2. Planned duct systems layout, including elbow radii and duct accessories.
3. Clearances for installing and maintaining insulation.
4. Clearances for servicing and maintaining equipment, accessories, and specialties, including space for disassembly required for periodic maintenance.
5. Equipment and accessory service connections and support details.
6. Exterior wall and foundation penetrations.
7. Fire-rated wall and floor penetrations.
8. Sizes and location of required concrete pads and bases.
9. Scheduling, sequencing, movement, and positioning of large equipment into building during construction.
10. Floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
11. Reflected ceiling plans to coordinate and integrate installation of air outlets and inlets, light fixtures, communication system components, sprinklers, and other ceiling-mounted items.
12. Access panel locations in ceilings/walls/floors.

1.4 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
   1. American Society for Testing and Materials
      a. ASTM A 53-98: Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
      b. ASTM B 32-96: Specification for Solder Metal
      c. ASTM B 813-93: Specification for Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube
      d. ASTM B 828-98: Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
      e. ASTM C 1107-97: Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
      f. ASTM C 1173-97: Specification for Flexible Transition Couplings for Underground Piping Systems
      g. ASTM D 1785-96b: Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
      h. ASTM D 2235-96a: Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings
      i. ASTM D 2564-96a: Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
      j. ASTM D 2672-96a: Specification for Joints for IPS PVC Pipe Using Solvent Cement
      k. ASTM D 2855-96: Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
      l. ASTM D 3139-98: Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
      m. ASTM F 402-93: Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermostatic Pipe and Fittings
      n. ASTM F 493-97: Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings
      o. ASTM F 656-96a: Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings
   2. American Water Works Association
      a. AWWA C110-98: Ductile-Iron and Gray-Iron Fittings, 3 In. through 48 In. (76 mm through 1219 mm), for Water and Other Liquids
      b. AWWA C219-97: Bolted, Sleeve-Type Couplings for Plain-End Pipe
   3. American Welding Society
      a. AWS A5.8-92: Specification for Filler Metals for Brazing and Braze Welding
      b. AWS D1.1-98: Structural Welding Code--Steel
      c. AWS D10.12-89: Recommended Practices and Procedures for Welding Low Carbon Steel Pipe

d. Brazing Handbook. 1991.

4. ASME International
   a. ASME B1.20.1-83 (Reaffirmed 1992): Pipe Threads, General Purpose (Inch)
   b. ASME B16.21-92: Nonmetallic Flat Gaskets for Pipe Flanges
   c. ASME B18.2.1-96: Square and Hex Bolts and Screws--Inch Series
   d. ASME B31 Series: Code for Pressure Piping
   e. 1998 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications"
5. Copper Development Association Inc.
   a. Copper Tube Handbook. 1995.
6. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.
   a. MSS SP-107-91: Transition Union Fittings for Joining Metal and Plastic Products

B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

C. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. Equipment of higher electrical characteristics, physical dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in writing and connecting mechanical and electrical services, circuit breakers, conduit, motors, bases, and equipment spaces are increased. Additional costs shall be approved in advance by appropriate Contract Modification for these increases. If minimum energy ratings or efficiencies of equipment are specified, equipment must meet design and commissioning requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, if stored inside.

C. Protect flanges, fittings, and piping specialties from moisture and dirt.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate phasing and sequencing of all work with the Owner and Building Engineer.

B. Coordinate mechanical equipment installation with other building components.

C. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction to allow for mechanical installations.

D. Coordinate installation of required supporting devices and sleeves in poured-in-place concrete and other structural components, as they are constructed.

E. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning before closing in building.

F. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

G. Coordinate requirements for access panels and doors if mechanical items requiring access are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

H. Coordinate installation of identifying devices after completing covering and painting, if devices are applied to surfaces. Install identifying devices before installing acoustical ceilings and similar concealment.

I. Coordinate connection of electrical services.

1.7 WARRANTY

A. Provide warranty on materials and labor for 18 months starting from date of delivery, or one year from date of substantial completion, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers:
   1. Dielectric Unions: No preference.
   2. Dielectric Flanges: No preference.
   3. Dielectric-Flange Insulating Kits: No preference.
   4. Dielectric Couplings: No preference.
   5. Dielectric Nipples: No preference.
   6. Mechanical Sleeve Seals:
      a. Calpico, Inc.
      b. Metraflex Co.
      c. Thunderline/Link-Seal.
   7. Metal, Flexible Connectors:
      a. Grinnell Corp.; Grinnell Supply Sales Co..
      b. Mercer Rubber Co.
      c. Metraflex Co.
   8. Rubber, Flexible Connectors:
      a. General Rubber Corp.
      b. Metraflex Co.
      c. Red Valve Co., Inc.
   9. Grooved Fittings:
      a. Grinnell Corp.; Grinnell Supply Sales Co.
      b. Victaulic Company of America.
      c. Central Sprinkler.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
   2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:
   1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.4 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.5 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

B. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   1. Pressure Plates: Carbon steel. Include two for each sealing element.
   2. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.6 FLEXIBLE CONNECTORS

A. General: Fabricated from materials suitable for system fluid and that will provide flexible pipe connections. Include 125-psig minimum working-pressure rating, unless higher working pressure is indicated, and ends according to the following:
   1. 2-Inch NPS and Smaller: Threaded.
   2. 2-1/2-Inch NPS and Larger: Flanged.
   3. Option for 2-1/2-Inch NPS and Larger: Grooved for use with keyed couplings.

B. Bronze-Hose, Flexible Connectors: Corrugated, bronze, inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze welded to hose.

C. Stainless-Steel-Hose/Steel Pipe, Flexible Connectors: Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include steel nipples or flanges, welded to hose. Do not use for potable water.

D. Stainless-Steel-Hose/Stainless-Steel Pipe, Flexible Connectors: Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to hose. Do not use for potable water.

E. Couplings may be used to provide allowance for controlled pipe movement, expansion, contraction, and or deflection to absorb movement for thermal changes, setting or seismic action and also vibration attenuation.

2.7 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral water-stop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Under-deck Clamp: Clamping ring with set screws.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.
1. Finish: Rough brass.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
1. Finish: Rough brass.

E. One-Piece, Stamped-Steel Type: With set screw and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw, and chrome-plated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 ACCESS PANELS

A. General: Refer to Division 08 Section, "Access Doors and Frames," for access panel manufacturers and other requirements.

2.10 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 MECHANICAL DEMOLITION

A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Demolition" for general demolition requirements and procedures.

B. Remove and cap all inactive or abandoned piping and ductwork in mechanical rooms. Larger duct and pipe located in accessible areas shall be removed and capped at the discretion of the contractor with concurrence of Owner and Building Engineer.

C. Disconnect, demolish, and remove mechanical systems, equipment, and components indicated on the drawings to be removed.
1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

D. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
   1. New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
      c. Insulated Piping: One-piece, stamped-steel type with spring clips.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
      e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type and set screw.
      f. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and set screw.
      g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw.
      h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
   2. Existing Piping: Use the following:
      a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
      b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge and spring clips.
      c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
      d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
      e. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
      f. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
      g. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

M. Sleeves are not required for core-drilled holes.

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
   3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
      a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
      b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.

c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
   1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

P. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Q. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

S. Verify final equipment locations for roughing-in.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Note internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
2. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
3. Align threads at point of assembly.
4. Tighten joint with wrench. Apply wrench to valve end into which pipe is being threaded.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Align flange surfaces parallel. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
   3. PVC Non-pressure Piping: Join according to ASTM D 2855.

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

K. Plastic Non-pressure Piping Gasketed Joints: Join according to ASTM D 3212.

L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
   1. Plain-End Pipe and Fittings: Use butt fusion.
   2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
   1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
   3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
   4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.

B. Install equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to Architect.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

D. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

E. Install equipment giving right of way to piping installed at required slope.

F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.

3.6 PAINTING AND FINISHING

A. Refer to Division 09 Section "Painting" for paint materials, surface preparation, and application of paint.

B. Do not paint piping specialties with factory-applied finish.

C. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of trades involved.

B. Repair cut surfaces to match adjacent surfaces.

3.8 GROUTING

A. Install nonmetallic, nonshrink, grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's written instructions.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placing of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases to provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout according to manufacturer's written instructions.

3.9 CLEANING

A. Coordinate general cleanup with the work as specified in Division 1.

3.10 ACCESS PANELS

A. Where control valves, shut-off valves, drip traps, heating coils, dampers, pull boxes or other specialties, which require service or adjustment, are installed above inaccessible type furred ceilings or within furred walls, the Trade Contractor whose equipment is involved shall furnish and install access panels as required.

B. Each Trade shall confer with other trades with respect to access panel locations, and shall wherever practical group valves, traps, dampers, etc. in such a way as to be accessible from a single panel and eliminate as many access panels as possible.

3.11 ERECTION

A. Provide all necessary rigging, scaffolding, tools, tackle, labor and other like items necessary for the complete installation of the equipment.

B. Adapt his work to job conditions and install his work to clear beams, joists and light fixtures, adjusting risers, avoiding interferences with windows and openings, raising or lowering work to permit the passing of ductwork or the work of other trades, all as required or as job conditions dictate, without additional costs to the Owner.

C. Trade Contractor shall not rig, tie to, or rest weight upon any part of the building or make use of any stairway until specific permission is obtained.

D. Permission to rig to or make use of any part of the building premises shall not relieve the contractor of responsibility for any damage.

E. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

F. Field Welding: Comply with AWS D1.1, "Structural Welding Code--Steel."

3.12 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage to support and anchor mechanical materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.13 FLASHINGS

A. Openings in roof shall be flashed with 40 lb. sheet lead, in one piece, extending 24" under roofing in all directions from drains, pipes, or ducts, with upper edge at least 8" above the roof and turned over and down into increaser or sleeve or over curb for at least 1" and tightly bound with nonferrous wire.
   1. All lead flashings shall be entirely painted with a good coat of black asphaltum before installation.
   2. Roof flashing must be approved in writing by the Roofing Trade contractor to the effect that such flashing will not void guarantees or bonds pertaining to the roofing contract.

3. Coordinate with the work under Division 07.

3.14 OPENINGS

A. Where temporary openings are necessary thru walls and partitions of the building for the entry or installation of tanks, fans, or other machinery or apparatus, or for driveways and other facilities, the permanent work of the mechanical trades at said openings shall be temporarily omitted and installed after equipment is brought into the building or after temporary facilities are removed.

B. Refer to other Sections of the Specifications for framing of openings for ducts, grilles, registers, etc., in walls, partitions, floors, roofs, etc. The trade for each service shall be responsible for locating and providing the proper dimensions for all required openings.
   1. Space between ducts and wall or floor openings shall be sealed as specified in Division 07 Section "Penetration Firestopping."

C. No cutting or drilling of any building structural members will be permitted, unless the specific extent and limits are approved, in writing, by the Architect.

D. All openings in the existing structure shall be core drilled with a diamond drill. The use of jackhammers will not be permitted.

E. The Contractor shall notify the Architect if any existing openings are uncovered adjacent to location of a new opening. The new opening shall not be drilled if the existing can be used unless directed by the Architect.

END OF SECTION

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes basic requirements for factory- and field-installed motors.

1.2 DEFINITIONS

A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

B. Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.3 SUBMITTALS

A. Product Data for Field-Installed Motors: For each type and size of motor, provide nameplate data and ratings; shipping, installed, and operating weights; enclosure type and mounting arrangements; size, type, and location of winding terminations; conduit entry and ground lug locations; and information on coatings or finishes.

B. Shop Drawings for Field-Installed Motors: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:
   1. Each installed unit's type and details.
   2. Nameplate legends.
   3. Diagrams of power, signal, and control wiring. Provide schematic wiring diagram for each type of motor and for each control scheme.

C. Qualification Data: For testing agency.

D. Source quality-control test reports.

E. Field quality-control test reports: Submit written reports documenting the activities required to be performed in PART 3. These reports are to be submitted two weeks after the startup is completed.

F. Training Reports: Submit reports on training documenting dates and attendance.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in PART 3.

B. Source Limitations: Obtain field-installed motors through one source from a single manufacturer.

C. Product Options for Field-Installed Motors: Drawings indicate size, profiles, and dimensional requirements of motors and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NFPA 70.

1.5 DELIVERY, STORAGE AND HANDLING

A. Follow manufacturer’s instructions for storage and handling of motors.

1.6 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices and features that comply with the following:
   1. Compatible with the following:
      a. Magnetic controllers.
      b. Multispeed controllers.
      c. Reduced-voltage controllers.

2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.
3. Matched to torque and horsepower requirements of the load.
4. Matched to ratings and characteristics of supply circuit and required control sequence.

B. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.

C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.7 WARRANTY

A. Written manufacturer's warranty covering parts and labor for a period of one year from substantial completion, or eighteen months from shipment, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following manufacturers:
1. Motors:
a. Baldor.
b. General Electric.
c. Lincoln Motors.
d. Marathon.
e. Reliance.
f. U.S. Motors.

2.2 MOTOR REQUIREMENTS

A. Motor requirements apply to factory- and field-installed motors except as follows:
1. Different ratings, performance, or characteristics for motor are specified in another Section.
2. Motorized-equipment manufacturer requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

2.3 MOTOR CHARACTERISTICS

A. Motors 1/2 HP and Larger: Three phase.

B. Motors Smaller Than 1/2 HP: Single phase.

C. Frequency Rating: 60 Hz.

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected. 208V motors shall be rated for continuous operation at 200V.

E. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.

F. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.

G. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

H. Enclosure: Open dripproof.

2.4 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium, as defined in NEMA MG 1.

C. Stator: Copper windings, unless otherwise indicated.
1. Multispeed motors shall have separate winding for each speed.

D. Rotor: Squirrel cage, unless otherwise indicated.

E. Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating, unless otherwise indicated.

G. Insulation: Class F, unless otherwise indicated.

H. Code Letter Designation:
1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

I. Enclosure: Cast iron for motors 7.5 hp and larger; rolled steel for motors smaller than 7.5 hp.
1. Finish: Gray enamel.

2.5 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Motors shall be inverter-duty. Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
1. Designed with critical vibration frequencies outside operating range of controller output.
2. Temperature Rise: Matched to rating for Class B insulation.
3. Insulation: Class F.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
5. Provide grounding rings to protect motor bearings from current damage.

C. Rugged-Duty Motors: Totally enclosed, with 1.25 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with non-hygroscopic material.
1. Finish: Chemical-resistant paint over corrosion-resistant primer.

D. Source Quality Control for Field-Installed Motors: Perform the following tests on each motor according to NEMA MG 1:
1. Measure winding resistance.
2. Read no-load current and speed at rated voltage and frequency.
3. Measure locked rotor current at rated frequency.
4. Perform high-potential test.

2.6 SINGLE-PHASE MOTORS

A. Type: One of the following, to suit starting torque and requirements of specific motor application:
1. Permanent-split capacitor.
2. Split-phase start, capacitor run.
3. Capacitor start, capacitor run.

B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.

C. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

D. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, pre-lubricated-sleeve type for other single-phase motors.

E. Source Quality Control for Field-Installed Motors: Perform the following tests on each motor according to NEMA MG 1:
1. Measure winding resistance.
2. Read no-load current and speed at rated voltage and frequency.
3. Measure locked rotor current at rated frequency.
4. Perform high-potential test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before motor installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

3.2 FIELD-INSTALLED MOTOR INSTALLATION

A. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.

B. Install motors on concrete bases complying with Division 03.

C. Comply with mounting and anchoring requirements specified in Division 23 Section "Vibration Controls for HVAC."

3.3 FIELD QUALITY CONTROL FOR FIELD-INSTALLED MOTORS

A. Prepare for acceptance tests.
1. Align motors, bases, shafts, pulleys, and belts. Tension belts according to manufacturer's written instructions.
2. Verify bearing lubrication.
3. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
4. Test interlocks and control and safety features for proper operation.
5. Verify that current and voltage for each phase comply with nameplate rating and NEMA MG 1 tolerances.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

C. Perform the following field tests and inspections and prepare test reports:
1. Perform electrical tests and visual and mechanical inspections including optional tests and inspections stated in NETA ATS on factory- and field-installed motors. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.4 CLEANING

A. Comply with applicable requirements in Division 23 Section "HVAC Equipment Cleaning."

3.5 CONTRACTOR STARTUP AND REPORTING

A. Prepare for acceptance tests.
1. Align motors, bases, shafts, pulleys, and belts. Tension belts according to manufacturer's written instructions.
2. Verify bearing lubrication.
3. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
4. Test interlocks and control and safety features for proper operation.
5. Verify that current and voltage for each phase comply with nameplate rating and NEMA MG 1 tolerances.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

C. Perform the following field tests and inspections and prepare test reports:
1. Perform electrical tests and visual and mechanical inspections including optional tests and inspections stated in NETA ATS on factory- and field-installed motors. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.6 DEMONSTRATION AND COMMISSIONING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain field-installed motors. Refer to Division 01 Section "Demonstration and Training."
1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining chillers. The training will occur after the startup report has been provided to the owner and the trainer will provide two (2) Installation and Operations manuals for the use of the owners personnel during training.

2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational trouble shooting. If the IOM does not include a written trouble shooting guide one will be provided.
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

B. Demonstrate proper operation of equipment to commissioning agent or designated owners personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control, as well as any commissioning requirements in Division 01 or 23.

END OF SECTION

MOTORS - VARIABLE FREQUENCY CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes solid-state, pulse-width modulated, variable frequency controllers and variable frequency drives for speed control of three-phase, squirrel-cage induction motors.

1.2 DEFINITIONS

A. EMS: Energy Management System.

B. IGBT: Integrated gate bipolar transistor.

C. LAN: Local area network.

D. PID: Control action, proportional plus integral plus derivative.

E. PWM: Pulse-width modulated.

F. VFC: Variable frequency controller and variable frequency drive.

1.3 PERFORMANCE REQUIREMENTS

A. Design – Environmental: Equipment shall be rated for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:
   1. Temperature Range, Ambient: 32 deg F to 105 deg F.
   2. Relative Humidity: Less than 90 percent (noncondensing).
   3. Altitude: Not exceeding 3300 feet.
   4. Conditions: Winter: -10 deg F DB; Summer: 95 deg F DB / 75 deg F WB.

B. Noise: The VFC shall not produce motor noise in excess of the manufacturers published noise standards for 60 Hz operation.

1.4 SUBMITTALS

A. Product Data: For each type of VFC. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

B. Shop Drawings:
   1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      a. Each installed unit's type and details.
      b. Nameplate legends.
      c. Short-circuit current rating of integrated unit.
      d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.
   2. Wiring Diagrams: Power, signal, and control wiring for VFCs. Provide schematic wiring diagram for each type of VFC.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs where pipe and ducts are prohibited. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Qualification Data: For manufacturer and testing agency.

E. Field Quality-Control Test Reports: Submit reports documenting the activities performed. These reports are to be submitted two weeks after startup is completed.

F. Operation and Maintenance Data: For VFCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. Include the following:
   1. Routine maintenance requirements for VFCs and all installed components.
   2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   3. A table listing the installed VFC drives set up parameters, alarm and trip setting.
   4. Complete parts list with stock numbers, including spare parts.

G. Training Reports: Submit reports on training documenting dates and attendance.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Award the work to a single firm that specializes in the production of variable frequency drives, with not less than 5 years experience in the production of variable frequency drives similar in design and performance to those required for the Project, and whose work has resulted in a history of successful in-service performance. The manufacturer shall have sufficient production capacity, and have organized quality control and testing procedures, to be capable of producing the equipment required for the Project without causing a delay in the Work. The manufacturer shall maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing.

C. Source Limitations: Obtain all VFCs required for the Project through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Regulatory Requirements: Comply with the Chicago Building Code, including requirements for components and installation.

F. Comply with IEEE 519-1992, "Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store VFCs in manufacturer's original protective packaging, with original labels detailing contents intact. Store VFCs indoors, off of ground, under cover, in clean, dry location with uniform temperature and humidity to prevent condensation. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.7 COORDINATION

A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances, including clearances required for maintenance, and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Deliver setting templates in time to allow casting of anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

D. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.8 COORDINATION WITH ENERGY MANAGEMENT SYSTEM

A. General: The equipment specified in this Section is required to be interfaced with the Energy Management System (EMS) as specified in Division 23 Section "Building Automation System." Provide all devices, hardware, programming, startup and commissioning required to establish the interface.

B. Coordinate with EMS supplier for their review and acceptance of the communications interface to be provided. Include evidence of the coordination and review process with the required submittals for this Section.

C. Provide a list of all read/write and read-only points available through the user interface. Provide software, hardware or paperwork that the contractor installing the EMS will require in order to accomplish the interface.

D. The equipment supplier is solely responsible for the proper performance of their equipment provided the correct information is provided through the communications interface.

E. Provide a prefunctional checklist, startup checklist and demonstration report to the Engineer, Commissioning Agent, or Board Authorized Representative for acceptance of system.

F. Provide a startup technician on-site during the establishment of the interface. Coordinate this activity with the EMS installer.

G. BACNet or LonWorks compliant manufacturer-provided controls
   1. Provide any information necessary to allow the BACNet compliant device to be directly connected to the existing network, and send/receive information to the system installed under Division 23 sections.
   2. The EMS shall then read and present the information made available by the equipment manufacturer, and transmit information receivable by the equipment manufacturer. This shall be accomplished by user configuration of point information, but shall not require recompiling or downloading of control programs.

H. Non-BACNet or LonWorks compliant manufacturer-provided controls:
   1. Provide programming and hardware necessary to integrate information from the equipment into the EMS.
   2. Provide the owner and EMS installer with all documentation necessary to receive point information required by Division 23 sections in a communications method compatible with the EMS.

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components or equipment that fail in materials or workmanship within the specified warranty period. Manufacturer's warranty shall include parts, labor, travel costs, and living expenses incurred by the manufacturer in providing onsite service and repair or replacement.
   1. Warranty Period: Three years from the date of Substantial Completion or Preliminary Acceptance.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed in the quantity indicated, in manufacturer's protective packaging, with manufacturer's original labels describing contents intact.
   1. Indicating Lights: Two of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:
   1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
   2. Danfoss.
   3. Toshiba International Corporation.

2.2 VARIABLE FREQUENCY CONTROLLERS

A. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
   1. Provide unit suitable for operation of premium-efficiency motor as defined by NEMA MG 1.

B. All PWM AC Variable Frequency Drives of 40 hp and above shall be equipped with harmonic mitigation equipment to prevent power system problems resulting from high levels of reflected harmonic distortion. Provide harmonic mitigation for drives less than 40 hp where required to meet IEEE 519.
   1. The harmonic mitigation equipment shall treat all of the characteristic low frequency harmonics generated by a 3-phase, diode bridge rectifier load (5th, 7th, 11th, 13th, etc.).
   2. The characteristic harmonics shall be suppressed without the need for individual tuning or the requirement to phase shift against other harmonic sources.
   3. Harmonic mitigation shall be by passive inductor/capacitor network or internal phase shifting transformer. Active electronic components shall not be used.

4. Power factor shall be 0.98 lagging to 0.95 leading in operating range from full to half load.
5. To ensure compatibility with engine generators, the harmonic mitigation equipment must never introduce a capacitive reactive power (KVAR) that is greater than 15% of its kVA rating.
6. The harmonic mitigation equipment shall not resonate with system impedances or attract harmonic currents from other harmonic sources.
7. The harmonic mitigation equipment in combination with the Variable Frequency Drive shall meet all requirements of IEEE 519 for individual and total harmonic voltage and current distortion. The Point of Common Coupling (PCC) for all voltage and current harmonic calculations and measurements shall be the input terminals to the harmonic mitigation equipment.
8. Total Harmonic Voltage Distortion (THVD) shall meet the requirements of Table 10.2 of IEEE 519 by not exceeding 5% and by limiting the individual harmonic voltage distortion to less than 3%. These limits shall apply while operating on either utility supply or generator supply when applicable. The harmonic mitigation equipment vendor shall not be responsible for pre-existing voltage distortion caused by other harmonic sources.
9. Total Demand Distortion (TDD) of the current at the input terminals of the harmonic mitigation equipment shall not exceed the limits as defined in Table 10.3 of IEEE 519. For Isc/IL ratio < 20, TDD must be less than 5%. For all other Isc/IL ratios, the TDD must not exceed 8% even when Table 10.3 allows for more relaxed limits. For single-phase applications, the TDD must not exceed 12%.
10. The full load efficiency of the harmonic mitigation equipment / VFD combination shall be greater than 96%. The harmonic mitigation equipment itself shall have efficiency no less than 99%.

C. Design and Rating: Match load type such as fans, blowers, and pumps, and type of connection used between motor and load, such as direct or through a power-transmission connection.

D. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

E. Unit Operating Requirements:
1. Input ac voltage ranges of 208 V, plus or minus 10 percent or 480 V, plus or minus 10 percent as indicated on equipment schedules.
2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
3. Minimum Efficiency: 96 percent at 60 Hz, full load.
4. Minimum Displacement Primary-Side Power Factor: 96 percent.
5. Overload Capability: 1.2 times the base load current for 60 seconds; 1.8 times the base load current for 3 seconds.
6. Starting Torque: 100 percent of rated torque or as indicated.
7. Speed Regulation: Plus or minus 1 percent.

F. Isolated Control Interface: To allow controller to follow control signal over an 11:1 speed range.
1. Electrical Signal: 4 to 20 mA at 24 V.

G. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 2 to a minimum of 22 seconds.
4. Deceleration: 2 to a minimum of 22 seconds.
5. Current Limit: 50 to a minimum of 110 percent of maximum rating.

H. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors.
2. Under- and overvoltage trips; inverter over-temperature, overload, and overcurrent trips.
3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 10 performance.
4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
5. Instantaneous line-to-line and line-to-ground overcurrent trips.
6. Loss-of-phase protection.
7. Reverse-phase protection.
8. Short-circuit protection.
9. Motor over temperature fault where motor is equipped with RTD.

MOTORS - VARIABLE FREQUENCY CONTROLLERS

I. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

J. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

K. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

L. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

M. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

N. Input Line Conditioning: dc bus link reactors, isolation transformers, active and passive harmonic filters, and phase shifting transformers.

O. VFC Output Filtering: Line inductors, output limit filters, sine wave filters, and motor termination filters shall be provided where the motor to drive conductor lengths exceed manufacturer's recommended lengths.

P. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

Q. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

R. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

S. Control Signal Interface:

T. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
1. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the EMS or other control systems:
a. 0 to 10-V dc.
b. 0-20 or 4-20 mA.
c. Potentiometer using up/down digital inputs.
d. Fixed frequencies using digital inputs.
e. RS485.
f. Keypad display for local hand operation.
2. Output Signal Interface:
a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
1) Output frequency (Hz).

2) Output current (load).
3) DC-link voltage (VDC).
4) Motor torque (percent).
5) Motor speed (rpm).
6) Set-point frequency (Hz).

3. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   a. Motor running.
   b. Set-point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

U. Communications: Provide an RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via EMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.

V. Integral Disconnecting Means: NEMA AB 1, molded-case switch with lockable handle.

W. Operation and Maintenance Features:
1. Current-Voltage-Frequency Indicating Devices: Mount meters or digital readout device and selector switch flush in controller door and connect to indicate controller output.
2. Manual Bypass: Magnetic contactor arranged to safely transfer the motor from the controller to the power line, or from the line to the controller while the motor is at zero speed. Include VFC-bypass selector switch and indicator lights to indicate mode selection. The operator shall have full control of the bypass starter by operation of the selector switch.
3. Integral Main Disconnect: Circuit breaker connected to shut down all power to both the controller and the bypass. Interlock breaker with cabinet door.
4. Auxiliary Motor Contactors: Electrically interlocked. One contactor connected between the controller output and the motor, controlled by the controller regulator; and one between the bypass power line and the motor, providing across-the-line starting capability in the bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.
5. Isolating Circuit Breaker: Arranged to electrically isolate the variable-speed controller to permit safe trouble-shooting and testing of the controller, both energized and de-energized, while the motor is operating in the bypass mode.
6. Form C output contacts for run and fault conditions.
7. Terminal strip for N.C. safety shutdown contacts.
8. N.C. input for remote start/stop control in Auto mode.

2.3 ENCLOSURES

A. Indoors: NEMA 250, Type 1.

B. Outdoors: NEMA 3R.

2.4 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Standard Displayed information, display shall be interchangeable for all VFCs installed:
1. Output frequency (Hz).
2. Set-point frequency (Hz).
3. Motor current (amperes).
4. DC-link voltage (VDC).
5. Motor torque (percent).
6. Motor speed (rpm).
7. Motor output voltage (V).
8. Fault history with analytical data.

E. Historical Logging Information and Displays:
   1. Real-time clock with current time and date.
   2. Running log of total power versus time.
   3. Total run time.
   4. Fault log, maintaining last four faults with time and date stamp for each.

F. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107.

2.5 FINISH

A. Finish: Manufacturer's standard paint finish, applied to factory-assembled and -tested VFCs.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Harmonic Analysis: Obtain the electrical system one-line diagram from the contract document, provide a harmonic analysis demonstrating that the proposed VFDs (along with harmonic mitigation equipment provided) conform with IEEE 519-1992, "Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems."

3.3 SELECTION

A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, minimum clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

B. Select features of each VFC to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.

C. Select horsepower rating of controllers to suit motor controlled.

3.4 INSTALLATION

A. Anchor each VFC assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.

B. Install VFCs on concrete bases.

C. VFD's are not to be installed inside air handlers or air plenums due to the potentially high humidity or temperatures.

3.5 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

3.6 IDENTIFICATION

A. Identify VFCs, components, and control wiring according to Division 23 Section "Mechanical Identification."

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.7 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices according to Division 26 sections. Power and control wiring shall not be run in the same conduit, and shall follow manufacturer's recommendations.

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where applicable.

1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.8 CONNECTIONS

A. Install conduit and ground equipment in accordance with Division 26 sections.

3.9 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain variable frequency controllers. Refer to Division 01 Section "Testing and Inspection."

B. Conduct a minimum of 4 hours of training in operation and maintenance of equipment.

C. Schedule training with at least seven days' advance notice.

3.11 CLEANING

A. Remove paint splatters and other spots, dirt and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally using methods and materials as recommended by manufacturer.

3.12 CONTRACTOR STARTUP AND REPORTING

A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Reports: Prepare written reports certified by testing organization of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include records of repairs and adjustments made. Harmonic compliance shall be verified with onsite field measurements of both the voltage and current harmonic distortion at the input terminals of the harmonic mitigating equipment with and without the equipment operating. A recording type Fluke 41 or equivalent harmonics analyzer displaying individual and total harmonic currents and voltages must be utilized.

C. Manufacturer’s Field Service: Engage a factory-authorized service representative to perform the following:
   1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
   2. Assist in field testing of equipment including pretesting and adjusting of solid-state controllers.
   3. Prepare written reports.

D. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
   1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.13 DEMONSTRATION AND COMMISSIONING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air handling units.
   1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining the equipment. The training will occur after the startup report has been provided to the owner and the trainer will provide two (2) Installation and Operations manuals for the use of the Owner's personnel during training.
   2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational troubleshooting. If the IOM does not include a written troubleshooting guide one shall be provided.
   3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

MOTORS - VARIABLE FREQUENCY CONTROLLERS

B. Demonstrate proper operation of equipment to commissioning agent or Owner's designated personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements in Divisions 01 and 23 sections.

END OF SECTION

EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Metal-bellows expansion joints.
2. Expansion compensators.
3. Rubber expansion joints.
4. Flexible-hose expansion joints.
5. Packed slip expansion joints.
6. Flexible ball joints.
7. Pipe bends and loops.
8. Alignment guides and anchors.

1.2 DEFINITIONS

A. BR: Butyl rubber.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Welding certificates.

C. Product Certificates: For each type of pipe expansion joint, signed by product manufacturer.

D. Maintenance Data: For pipe expansion joints to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:
1. Steel Shapes and Plates: AWS D1.1, "Structural Welding Code - Steel."

1.5 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping system fluids, materials, working pressures, and temperatures.

B. Capability: Products shall absorb 200 percent of maximum axial movement between anchors.

PART 2 - PRODUCTS

2.1 EXPANSION JOINTS

A. Subject to compliance with requirements, provide products by one of the following:
1. Metal Bellows Expansion Joints:
a. Hyspan Precision Products, Inc.
b. Metraflex, Inc.
c. Piping Technology and Products, Inc.
d. Senior Flexonics, Inc.; Pathway Division.
2. Expansion compensators:
a. Flex-Weld, Inc.
b. Hyspan Precision Products, Inc.
c. Metraflex, Inc.
d. Senior Flexonics, Inc.; Pathway Division.
3. Rubber expansion joints:
a. Mason Industries, Inc.; Mercer Rubber Co.
b. Metraflex, Inc.
c. Senior Flexonics, Inc.; Pathway Division.
4. Flexible-hose expansion joints:
a. Flex-Hose Co., Inc.
b. Flexicraft Industries.
c. Metraflex, Inc.
5. Packed slip expansion joints:
a. Adsco Manufacturing, LLC.
b. Advanced Thermal Systems, Inc.

c. Hyspan Precision Products, Inc.

6. Flexible ball joints:
   a. Advanced Thermal Systems, Inc.
   b. Hyspan Precision Products, Inc.
7. Alignment guides and anchors:
   a. Hyspan Precision Products, Inc.
   b. Metraflex, Inc.
   c. Piping Technology and Products, Inc.
   d. Senior Flexonics, Inc.; Pathway Division.

B. Metal-Bellows Expansion Joints: ASTM F 1120, circular-corrugated-bellows type with external tie rods.
1. Metal-Bellows Expansion Joints for Copper Piping: Multiple-ply phosphor-bronze bellows, copper pipe end connections, and brass shrouds.
2. Metal-Bellows Expansion Joints for Steel Piping: Multiple-ply stainless-steel bellows, steel pipe end connections, and carbon-steel shroud.
3. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
4. Configuration: Double-bellows type with base, unless otherwise indicated.
5. End Connections: Flanged or welded.

C. Expansion Compensators: Double-ply corrugated steel, stainless-steel, or copper-alloy bellows in a housing with internal guides, anti-torque device, and removable end clip for positioning.
1. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
2. Configuration for Copper Piping: Two-ply phosphor-bronze or stainless-steel bellows and bronze or stainless-steel shroud.
3. Configuration for Steel Piping: Two-ply stainless-steel bellows and carbon-steel shroud.
4. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint.
5. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Solder joint.
6. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
7. End Connections for Steel Pipe NPS 2-1/2 to NPS 4: Flanged or threaded.

D. Rubber Expansion Joints: ASTM F 1123, fabric-reinforced rubber with external control rods and complying with FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
1. Arch Type: Multiple arches.
2. Spherical Type: Multiple spheres.
   a. Minimum Pressure and Temperature Ratings for NPS 1-1/2 to NPS 4: 150 psig.
   b. Minimum Pressure and Temperature Ratings for NPS 5 and NPS 6: 140 psig at 200 deg F.
   c. Minimum Pressure and Temperature Ratings for NPS 8 to NPS 12: 140 psig at 180 deg F.
3. Material: BR.
4. End Connections: Full-faced, integral, steel flanges with steel retaining rings.

E. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.
1. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder-joint end connections.
   a. NPS 2 and Smaller: Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F and 500 psig at 450 deg F ratings.
   b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F and 315 psig at 450 deg F ratings.
2. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 and smaller and flanged end connections for NPS 2-1/2 and larger.
   a. NPS 2 and Smaller: Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F and 515 psig at 600 deg F ratings.
   b. NPS 2-1/2 to NPS 6: Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F and 200 psig at 600 deg F ratings.
   c. NPS 8 and Larger: Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.

F. Packed Slip Expansion Joints: ASTM F 1007, carbon-steel, packing type designed for repacking under pressure and pressure rated for 250 psig at 400 deg F minimum. Include asbestos-free PTFE packing, compound limit stops, and drip connection if used for steam piping.
   1. Configuration: Double-joint class with base, unless otherwise indicated.
   2. End Connections: Flanged or weld ends to match piping system.

G. Flexible Ball Joints: Carbon-steel assembly with asbestos-free composition packing, designed for 360-degree rotation and angular deflection, and 250 psig at 400 deg F minimum pressure rating; complying with ASME Boiler and Pressure Vessel Code: Section II, "Materials," and with ASME B31.9, "Building Services Piping," for materials and design of pressure-containing parts and bolting.
   1. Angular Deflection for NPS 6 and Smaller: 30-degree minimum.
   2. Angular Deflection for NPS 8 and Larger: 15-degree minimum.
   3. End Connections for NPS 2 and Smaller: Threaded.
   4. End Connections for NPS 2-1/2 and Larger: Flanged.

2.2 ALIGNMENT GUIDES

A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

2.3 MATERIALS FOR ANCHORS

A. Steel Shapes and Plates: ASTM A 36/A 36M.

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.
   1. Stud: Threaded, zinc-coated carbon steel.
   2. Expansion Plug: Zinc-coated steel.
   3. Washer and Nut: Zinc-coated steel.

E. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.
   1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
   2. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
   3. Washer and Nut: Zinc-coated steel.

F. Concrete: Portland cement mix, 3000 psi minimum. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.

G. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink, nonmetallic grout; suitable for interior and exterior applications.
   1. Properties: Nonstaining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi 28-day compressive strength.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

A. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

B. Install expansion joints of sizes matching size of piping in which they are installed.

C. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

3.2 PIPE BEND AND LOOP INSTALLATION

A. Attach pipe bends and loops to anchors.
   1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

3.3 SWING CONNECTIONS

A. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

C. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.4 ALIGNMENT-GUIDE INSTALLATION

A. Install guides on piping adjoining pipe expansion fittings and loops.

B. Attach guides to pipe and secure to building structure.

3.5 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints or compensators are indicated.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

END OF SECTION

METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Thermometers.
2. Gages.
3. Test plugs.
4. Thermowells.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated; include scale range, ratings, and calibrated performance curves, certified where indicated. Submit a meter and gauge schedule showing manufacturer’s figure number, scale range, location, and accessories for each meter.

B. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.

C. Product Certificates: For each type of thermometer and gage, signed by product manufacturer.

1.3 QUALITY ASSURANCE

A. Comply with applicable portions of American Society of Mechanical Engineers (ASME) and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gages, including the following:
1. ASME B40.3, "Bimetallic Actuated Thermometers."
2. ASME B40.5, "Snubbers."
3. ASME B40.100 , "Pressure Gauges and Gauge Attachments."
4. ASTM E 1, "Liquid-in-Glass Thermometers."

B. Design Criteria: The Drawings indicate types, sizes, capacities, ranges, profiles, connections, and dimensional requirements of meters and gages and are based on the specific manufacturer types and models indicated. Meters and gages having equal performance characteristics by other manufacturers may be considered, provided that deviations do not change the design concept or intended performance as judged by the Architect. The burden of proof for equality of meters and gages is on the proposer.

1.4 DELIVERY, STORAGE AND HANDLING

A. Follow manufacturer’s instructions for job site storage and protection of materials during construction.

PART 2 - PRODUCTS

2.1 Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers indicated.

A. Metal-Case, Liquid-in-Glass Thermometers:
1. Palmer - Wahl Instruments Inc.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.
4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Duct-Type, Liquid-in-Glass Thermometers:
1. Miljoco Corp.
2. Palmer - Wahl Instruments Inc.
3. Trerice, H. O. Co.
4. Weiss Instruments, Inc.

C. Direct-Mounting, Vapor-Actuated Dial Thermometers:
1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.

D. Remote-Mounting, Vapor-Actuated Dial Thermometers:
1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Trerice, H. O. Co.

3. Weiss Instruments, Inc.

E. Bimetallic-Actuated Dial Thermometers:
1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.

F. Thermowells:
1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.

G. Pressure Gages:
1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.

H. Test Plugs:
1. MG Piping Products Co.
2. Trerice, H. O. Co.
3. Watts Industries, Inc.; Water Products Div.

2.2 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

A. General: Provide liquid-in-glass thermometers complying with ASTM E1.

B. Case: Die-cast aluminum, 9 inches long.

C. Tube: Red reading, organic-liquid filled, with magnifying lens.

D. Tube Background: Satin-faced, non-reflective aluminum with permanently etched scale markings.

E. Window: Glass.

F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.3 DUCT-TYPE, LIQUID-IN-GLASS THERMOMETERS

A. Case: Die-cast aluminum, 7 inches long.

B. Tube: Red reading, organic filled, with magnifying lens.

C. Tube Background: Satin-faced, non-reflective aluminum with permanently etched scale markings.

D. Window: Glass.

E. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

F. Stem: Metal, for installation in mounting bracket and of length to suit installation.

G. Mounting Bracket: Flanged fitting for attachment to duct and made to hold thermometer stem.

H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.4 DIRECT-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS

A. Case: Drawn steel or cast aluminum metal or plastic, 4-1/2-inch diameter.

B. Element: Bourdon tube or other type of pressure element.

C. Movement: Mechanical, connecting element and pointer.

D. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.

E. Pointer: Red metal.

F. Window: Glass.

G. Ring: Metal.

H. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

I. Thermal System: Organic liquid-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.

J. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.5 REMOTE-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS

A. Case: Dry type, drawn steel or cast aluminum, 4-1/2-inch diameter with holes for panel mounting.

B. Element: Bourdon tube or other type of pressure element.

C. Movement: Mechanical, connecting element and pointer.

D. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.

E. Pointer: Red metal.

F. Window: Glass.

G. Ring: Metal.

H. Connector: Bottom union type.

I. Thermal System: Organic liquid-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.

J. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.6 BIMETALLIC-ACTUATED DIAL THERMOMETERS

A. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3.

B. Case: Dry type, stainless steel with 5-inch diameter.

C. Element: Bimetal coil.

D. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.

E. Pointer: Red metal.

F. Window: Glass.

G. Ring: Stainless steel.

H. Connector: Adjustable angle type.

I. Stem: Metal, for thermowell installation and of length to suit installation.

J. Thermal System: Organic liquid-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.

K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.7 THERMOWELLS

A. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

B. Stem length: Extend 2 inches into the fluid or into the center of the pipe. Extension for insulated pipe shall be 2 inches nominal, but not less than the thickness of the insulation.

C. Provide threaded cap nut with chain permanently fastened to well and cap.

2.8 PRESSURE GAGES

A. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
   1. Case: Dry type, drawn steel or cast aluminum, 4-1/2-inch diameter.
   2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
   3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.

4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.
6. Pointer: Red metal.
7. Window: Glass.
8. Ring: Metal.
9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

B. Pressure-Gage Fittings:
1. Valves: NPS 1/4 brass or stainless-steel needle type.
2. Syphons: NPS 1/4 coil of brass tubing with threaded ends.
3. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.9 TEST PLUGS

A. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

B. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

C. Core Inserts: One or two self-sealing rubber valves.
1. Insert material for air, water, oil, or gas service at 20 to 200 deg F shall be CR.
2. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.

D. Test Kit: Furnish one test kit containing one pressure gage and adaptor, two thermometers, and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.
1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch diameter dial and probe. Dial range shall be 0 to 200 psig.
2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F.
3. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F.
4. Carrying case shall have formed instrument padding.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install liquid-in-glass thermometers in the following locations and elsewhere as noted:
1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
4. Inlet and outlet of each hydronic heat exchanger.
5. Outside-air, return-air, and mixed-air ducts.
6. As indicated on Drawings.

B. Install direct-mounting, vapor-actuated dial thermometers in the following locations and elsewhere as noted:
1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
4. Inlet and outlet of each hydronic heat exchanger.
5. As indicated on Drawings.

C. Install bimetallic-actuated dial thermometers in the following locations:
1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
4. Inlet and outlet of each hydronic heat exchanger.
5. As indicated on Drawings.

D. Install dry-case-type, vapor-actuated dial thermometers at suction and discharge of each pump and as indicated on Drawings.

E. Provide the following temperature ranges for thermometers:
   1. Heating Hot Water (Condensing boiler applications): 30 to 220 deg F, with 2-degree scale divisions (Minus 1 to plus 150 deg C, with 1-degree scale divisions).
   2. Condenser Water: 0 to 160 deg F, with 2-degree scale divisions (Minus 18 to plus 71 deg C, with 1-degree scale divisions).
   3. Geo exchange and Chilled Water: 0 to 100 deg F, with 2-degree scale divisions (Minus 18 to plus 38 deg C, with 1-degree scale divisions).
   4. Air Ducts: Minus 40 to plus 110 deg F, with 2-degree scale divisions (Minus 40 to plus 43 deg C, with 1-degree scale divisions).
   5. Domestic Cold Water: 30 to 240 deg F, with 2-degree scale divisions (Minus 1 to plus 115 deg C, with 1-degree scale divisions).
   6. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions (Minus 18 to plus 38 deg C, with 1-degree scale divisions).

3.2 GAGE APPLICATIONS

A. Install dry-case-type pressure gages for discharge of each pressure-reducing valve.

B. Install dry-case-type pressure gages at chilled- and condenser-water inlets and outlets of chillers.

C. Install dry-case-type pressure gages at suction and discharge of each pump.

D. Install gages as indicated on Drawings.

3.3 INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions.

B. Install remote-mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.

C. Install thermowells with socket extending to center of pipe and in vertical position in piping tees where thermometers are indicated.

D. Duct Thermometer Support Flanges: Install in wall of duct where duct thermometers are indicated. Attach to duct with screws.

E. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

F. Install remote-mounting pressure gages on panel.

G. Install needle-valve and snubber fitting in piping for each pressure gage for fluids (except steam).

H. Install needle-valve and syphon fitting in piping for each pressure gage for steam.

I. Install test plugs in tees in piping. Provide a test plug at every thermometer and pressure gage location, and where indicated on the Drawings.

J. Install permanent indicators on walls or brackets in accessible and readable positions.

K. Install connection fittings for attachment to portable indicators in accessible locations.

3.4 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines, and equipment.

B. Apply conductive pate to the thermometer or temperature sensor prior to installing it in the thermowell.

3.5 ADJUSTING

A. Calibrate meters according to manufacturer's written instructions, after installation.

B. Adjust faces of meters and gages to proper angle for best visibility.

END OF SECTION

GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following general-duty valves:
1. Copper-alloy ball valves.
2. Ferrous-alloy butterfly valves.
3. Bronze check valves.
4. Ferrous-alloy wafer check valves.
5. Bronze gate valves.
6. Cast-iron gate valves.
7. Bronze globe valves.
8. Cast-iron globe valves.
9. Cast-iron plug valves.
10. Chainwheel actuators.

1.2 DEFINITIONS

A. The following are standard abbreviations for valves:
1. CWP: Cold working pressure.
2. EPDM: Ethylene-propylene-diene terpolymer rubber.
3. NBR: Acrylonitrile-butadiene rubber.
4. PTFE: Polytetrafluoroethylene plastic.
5. SWP: Steam working pressure.
6. TFE: Tetrafluoroethylene plastic.

1.3 SUBMITTALS

A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.4 QUALITY ASSURANCE

A. ASME Compliance: ASME B31.9 for building services piping valves.

B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

C. NSF Compliance: NSF 61 for valve materials for potable-water service.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:
1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide valves by one of the following:

B. Bronze ball valves:

1. Conbraco Industries, Inc.; Apollo Div.
2. Crane Co.; Crane Valve Group; Stockham Div.
3. NIBCO INC.
4. Watts Industries, Inc.; Water Products Div.

C. Ferrous-alloy butterfly valves:
1. Crane Co.; Crane Valve Group; Stockham Div.
2. Milwaukee Valve Company.
3. NIBCO INC.
4. Watts Industries, Inc.; Water Products Div.

D. Bronze check valves:
1. Crane Co.; Crane Valve Group; Stockham Div.
2. Milwaukee Valve Company.
3. NIBCO INC.
4. Watts Industries, Inc.; Water Products Div.

E. Ferrous-alloy wafer check valves:
1. Crane Co.; Crane Valve Group; Stockham Div.
2. NIBCO INC.
3. Watts Industries, Inc.; Water Products Div.

F. Bronze gate valves:
1. Crane Co.; Crane Valve Group; Stockham Div.
2. Milwaukee Valve Company.
3. NIBCO INC.

G. Cast-iron gate valves:
1. Crane Co.; Crane Valve Group; Stockham Div.
2. Milwaukee Valve Company.
3. NIBCO INC.
4. Watts Industries, Inc.; Water Products Div.

H. Bronze globe valves:
1. Crane Co.; Crane Valve Group; Stockham Div.
2. Milwaukee Valve Company.
3. NIBCO INC.

I. Cast-iron globe valves.
1. Crane Co.; Crane Valve Group; Stockham Div.
2. Milwaukee Valve Company.
3. NIBCO INC.

J. Cast-iron plug valves.
1. General Signal; DeZurik Unit.
2. Grinnell Corporation.
3. Tyco International, Ltd.; Tyco Valves and Controls.

K. Chainwheel actuators:
1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries, Inc.

2.2 VALVES, GENERAL

A. Refer to PART 3 "Valve Applications" Article for applications of valves.

B. Bronze Valves: NPS 2 and smaller with threaded ends, unless otherwise indicated.

C. Ferrous Valves: NPS 2-1/2 and larger with flanged ends, unless otherwise indicated.

D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

F. Valve Actuators:

1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in PART 3.
2. Gear Drive: For quarter-turn valves NPS 8 and larger.
3. Handwheel: For valves other than quarter-turn types.
4. Lever Handle: For quarter-turn valves NPS 6 and smaller, except plug valves.
5. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.

G. Valves in insulated piping shall have 2-inch stem extensions and the following features:
1. Gate valves shall be rising stem type.
2. Ball valves shall have extended operating handle of no-thermal conductive material, protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation, and memory stops that are fully adjustable after insulation is applied.
3. Butterfly valves shall have extended necks.

H. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

I. Valve Grooved Ends: AWWA C606.
1. Solder Joint: With sockets according to ASME B16.18.
a. Caution: Use solder with melting point below 840 deg F for angle, check, gate, and globe valves; below 421 deg F for ball valves.
2. Threads shall be in accordance with ASME B1.20.1.

J. Valve bypass and drain connections shall follow MSS SP-45.

2.3 BRONZE BALL VALVES

A. Ball Valves, 4 Inches and Smaller: MSS SP-110, Class 150, 600-psi CWP, ASTM B 584 bronze body and bonnet, 2-piece construction; chrome-plated brass ball, standard port for 1/2-inch valves and smaller and conventional port for 3/4-inch valves and larger; blowout proof; bronze or brass stem; teflon seats and seals; threaded or soldered end connections:
1. Operator: Steel handwheel.
2. Stem Extension: For valves installed in insulated piping.
3. Memory Stop: For operator handles.

2.4 FERROUS-ALLOY BUTTERFLY VALVES

A. General: MSS SP-67, Type I, for tight shutoff, with disc and lining suitable for potable water, unless otherwise indicated. 200-psi CWP, 150-psi maximum pressure differential, ASTM A 126 cast-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals, wafer, lug, or grooved style:
1. Disc Type: Nickel-plated ductile iron, Aluminum bronze, elastomer-coated ductile iron or epoxy-coated ductile iron.
2. Operator for Sizes 2 Inches to 6 Inches: Standard lever handle with memory stop.
3. Operator for Sizes 8 Inches to 24 Inches: Gear operator with position indicator.
4. Operator for Sizes 8 Inches and Larger, 96 Inches or Higher above Floor: Chain-wheel operator.

2.5 BRONZE CHECK VALVES

A. Swing Check Valves, 2-1/2 Inches and Smaller: MSS SP-80; Class 125, 200-psi CWP, or Class 150, 300-psi CWP; horizontal swing, Y-pattern, ASTM B 62 cast-bronze body and cap, rotating bronze disc with rubber seat or composition seat, threaded or soldered end connections:

B. Swing Check Valves, 3 Inches and Larger: MSS SP-71, Class 125, 200-psi CWP, ASTM A 126 cast-iron body and bolted cap, horizontal-swing bronze disc, flanged or grooved end connections.

2.6 WAFER CHECK VALVES

A. Class 125, 200-psi CWP, ASTM A 126 cast-iron body, bronze disc/plates, stainless-steel pins and springs, Buna N seals, installed between flanges.

2.7 BRONZE GATE VALVES

A. Gate Valves, 2-1/2 Inches and Smaller: MSS SP-80; Class 125, 200-psi cold working pressure (CWP), or Class 150, 300-psi CWP; ASTM B 62 cast-bronze body and bonnet, solid-bronze wedge, copper-silicon

alloy rising stem, teflon-impregnated packing with bronze packing nut, threaded or soldered end connections; and with aluminum or malleable-iron handwheel.

2.8 CAST IRON GATE VALVES

A. Gate Valves, 3 Inches and Larger: MSS SP-70, Class 125, 200-psi CWP, ASTM A 126 cast-iron body and bonnet, solid cast-iron wedge, brass-alloy stem, outside screw and yoke, teflon-impregnated packing with 2-piece packing gland assembly, flanged end connections; and with cast-iron handwheel.

2.9 BRONZE GLOBE VALVES

A. Globe Valves, 2-1/2 Inches and Smaller: MSS SP-80; Class 125, 200-psi CWP, or Class 150, 300-psi CWP; ASTM B 62 cast-bronze body and screwed bonnet, rubber, bronze, or teflon disc, silicon bronze-alloy stem, teflon-impregnated packing with bronze nut, threaded or soldered end connections; and with aluminum or malleable-iron handwheel.

2.10 CAST-IRON GLOBE VALVES

A. Globe Valves, 3 Inches and Larger: MSS SP-85, Class 125, 200-psi CWP, ASTM A 126 cast-iron body and bolted bonnet with bronze fittings, renewable bronze seat and disc, brass-alloy stem, outside screw and yoke, teflon-impregnated packing with cast-iron follower, flanged end connections; and with cast-iron handwheel.

2.11 CAST-IRON PLUG VALVES

A. Plug Valves: MSS SP-78, 175-psi CWP, ASTM A 126 cast-iron body and bonnet, cast-iron plug, Buna N, Viton, or teflon packing, flanged or grooved end connections:
   1. Operator: Lever.
   2. Operator: Worm and gear with handwheel, sizes 6 inches and larger.
   3. Operator: Worm and gear with chain wheel, sizes 6 inches and larger, 96 inches or higher above floor.

2.12 CHAINWHEEL ACTUATORS

A. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
   1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.
   2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
   3. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE APPLICATIONS

A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:
   1. Shutoff Service: Ball, butterfly, or gate or plug valves.
   2. Throttling Service: Ball, butterfly, or globe valves.
   3. Pump Discharge: Spring-loaded, lift-disc check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

C. Geothermal and Chilled-Water Piping: Use the following types of valves:
1. Ball Valves, NPS 2 and Smaller: 600-psig CWP rating, copper alloy.
2. Butterfly Valves, NPS 2-1/2 and Larger: Flanged, 150-psig CWP rating, ferrous alloy, with EPDM liner.
3. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 125, bronze.
4. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
5. Wafer Check Valves, NPS 2-1/2 and Larger: Single-plate, wafer, Class 125 or 150 ferrous alloy.
6. Gate Valves, NPS 2 and Smaller: Type 2, Class 125, bronze.
7. Gate Valves, NPS 2-1/2 and Larger: Type I, Class 125, OS and Y, bronze-mounted cast iron.
8. Globe Valves, NPS 2 and Smaller: Type 2, Class 150, bronze.
9. Globe Valves, NPS 2-1/2 and Larger: Type I, Class 125, bronze-mounted cast iron.

D. Heating Water Piping: Use the following types of valves:
1. Ball Valves, NPS 2 and Smaller: Two-piece, 600-psig CWP rating, copper alloy.
2. Ball Valves, NPS 2-1/2 and Larger: Class 150, ferrous alloy.
3. Butterfly Valves, NPS 2-1/2 and Larger: Flanged, 150-psig CWP rating, ferrous alloy, with EPDM liner.
4. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 125, bronze.
5. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
6. Wafer Check Valves, NPS 2-1/2 and Larger: Single-plate, double-flanged Class 125, ferrous alloy.
7. Gate Valves, NPS 2 and Smaller: Type 2, Class 125, bronze.
8. Gate Valves, NPS 2-1/2 and Larger: Type I, Class 125, OS and Y, bronze-mounted cast iron.
9. Globe Valves, NPS 2 and Smaller: Type 2, Class 125, bronze.
10. Globe Valves, NPS 2-1/2 and Larger: Type I, Class 125, bronze-mounted cast iron.

E. Select valves, except wafer and flangeless types, with the following end connections:
1. For Copper Tubing, NPS 2 and Smaller: Solder-joint or threaded ends, except provide valves with threaded ends for heating hot water, steam, and steam condensate services.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged or threaded ends.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged or threaded ends.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.3 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full stem movement.

F. Install chainwheel operators on valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor elevation.

G. Install check valves for proper direction of flow and as follows:
1. Swing Check Valves: In horizontal position with hinge pin level.

3.4 JOINT CONSTRUCTION

A. Refer to Division 23 Section "Basic HVAC Materials and Methods" for basic piping joint construction.

B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

GENERAL-DUTY VALVES FOR HVAC PIPING

3.5 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

END OF SECTION

HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following hangers and supports for mechanical system piping and equipment:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Rooftop Pipe Supports.
   7. Pipe positioning systems.

1.2 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.3 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Thermal-hanger shield inserts.
   3. Powder-actuated fastener systems.
   4. Pipe positioning systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
   1. Trapeze pipe hangers. Include Product Data for components.
   2. Metal framing systems. Include Product Data for components.
   3. Rooftop Pipe Supports. Include Product Data for components.
   4. Equipment supports.

C. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel." and ASME Boiler and Pressure Vessel Code: Section IX.

1.5 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

1.6 WARRANTY

A. Provide warranty on materials and labor for 18 months starting from date of delivery, or one year from date of substantial completion, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers:
   1. Steel Pipe Hangers and Supports:
      a. Anvil
      b. B-Line Systems, Inc.; a division of Cooper Industries.
      c. Carpenter and Paterson, Inc.
   2. Powder-Actuated Fasteners:
      a. Hilti, Inc.
      b. ITW Ramset/Red Head.
   3. Mechanical-Expansion Anchors:
      a. B-Line Systems, Inc.; a division of Cooper Industries.

b. Hilti, Inc.
c. ITW Ramset/Red Head.

4. Rooftop Pipe Supports:
   a. Pate
   b. RPS
   c. Thybar
5. Thermal-Hanger Shield Inserts:
   a. Carpenter and Paterson, Inc.
   b. PHS Industries, Inc.
   c. Pipe Shields, Inc.
6. Pipe Positioning Systems:
   a. C and S Mfg. Corp.
   b. HOLDRITE Corp.; Hubbard Enterprises.
   c. Samco Stamping, Inc.

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to PART 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Corrosion Protection: Hangers and components shall be galvanized or painted with carbo-zinc #11.

C. Threads: All threads shall be UNC unless otherwise specified.

D. Heat Transmission: Supports, guides and anchors shall limit the amount of heat transmitted to the structural steel. Temperature of supporting parts shall be based on a 100°F per inch temperature gradient from the outside pipe surface.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.5 ROOFTOP PIPE SUPPORTS

A. Description: Provide factory-fabricated steel sheet structural mounting supports. Construction shall include a welded 18-gauge galvanized steel shell, base plate and removable counterflashing. Support shall include a factory-installed wood nailer and internal bulkhead reinforcement. End sections shall be fully mitered. Support shall be compatible with insulated roof decks and include a 3 inch cant and variable step to match deck insulation thickness. The pipe roller assembly shall have galvanized 18 inches long continuous threaded rods to permit 12 inch vertical adjustments and a galvanized removable pipe retainer bracket.

2.6 THERMAL-HANGER SHIELD INSERTS

A. Description: 100 psig minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.7 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, system of metal brackets, clips, and straps for positioning piping in pipe spaces for plumbing fixtures for commercial applications.

2.8 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   1. Properties: Nonstaining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish. Hangers installed outdoors shall have two coats of rust inhibitor paint after installation and adjustment.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated stationary pipes, NPS 1/2 to NPS 30.
   2. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
   3. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
   4. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
   2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
   3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
   4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
   5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
   2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
   3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
   4. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
   5. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

6. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
7. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
8. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
9. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
10. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb (340 kg).
    b. Medium (MSS Type 32): 1500 lb (680 kg).
    c. Heavy (MSS Type 33): 3000 lb (1360 kg).
11. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
12. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
13. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

K. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

L. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

M. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

N. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

3.2 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
3. Trapeze bars shall be tightly secured to structural members at two points with bolts or other similar mechanical fasteners. Hangers from bar joist and fabricated truss members shall be located at the panel points of the structural members. C-clamp type hangers attached to one side of double-angle bottom members are not allowed. Point loads shall not exceed the lesser of:
    a. Manufacturer’s certified recommendation for the component parts.
    b. The following maximum point loads, and maximum hanger spacings as herein specified, for structural elements in any direction; except as specifically approved by the Structural Engineer of Record:

Structural Element Type	Maximum Hanger Point Load (lb)
Metal deck without concrete topping	50
Composite metal deck slab with concrete topping	50

HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT

Steel Beams:	
All channels, W4 through W8	100
W10 through W14	200
W16 through W24	400
W27 through W36	750
Built-up structural steel trusses	250
Reinforced post-tensioned concrete elements	
Slabs up to 6 inches thick	150
Slabs over 6 inches thick	250
Joists 8 inches wide	250
Beam/girders 8 inches wide	500

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:
   1. Drive screws, pins, studs, etc., of the type which are secured in place by means of explosive force may be used as a means of securing any of the hangers subject to the following:
      a. The stud, pin or fastener shall be caused to have a velocity not in excess of 300 feet per second when measured 6-1/2 feet from the muzzle of the tool by accepted ballistic test methods.
      b. Only workmen qualified by instructions of the manufacturers representative and/or licensed by the state and local authorities shall be assigned to use a powder actuated fastening tool.
      c. Where practical, tools of only one manufacturer shall be used on a project.
      d. Only cartridges and fasteners supplied by the manufacturer of the tool shall be used to operate that tool.
      e. Powder actuated fastening tools shall be handled with the same care as firearms.
      f. All safety devices incorporated in the tool by the manufacturer shall be used at all times.
      g. Acceptable types of powder actuated fastening tools are:
         1) Piston Tool - Low Velocity Type - is a tool utilizing a piston, activated by the power of a blank cartridge furnished by the manufacturer for use with it, to drive a stud, pin or fastener into a work surface.
         2) Powder Assisted Hammer Drive Tool - Low Velocity Type - is a tool utilizing a captive piston, activated by a blow from a 4 lb. hammer supplemented by the power of a blank cartridge furnished by the manufacturer for use with the tool, to drive a stud, pin or fastener into a work surface.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Division 22 Section "Plumbing Fixtures" for plumbing fixtures.

G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

J. Install lateral bracing with pipe hangers and supports to prevent swaying.

K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

L. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

N. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   4. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
      b. NPS 4: 12 inches long and 0.06 inch thick.
      c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
      d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
      e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
   5. Pipes NPS 8 and Larger: Include wood inserts.
   6. Insert Material: Length at least as long as protective shield.
   7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
   2. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish. Hangers installed outdoors shall have two coats of rust inhibitor paint after installation and adjustment.
   3. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

NOISE AND VIBRATION CONTROL FOR HVAC SYSTEMS

PART 1- GENERAL

1.1 SECTION INCLUDES

A. Isolation of vibration induced by HVAC Systems from spaces for which Noise Criteria have been established in Division 1, including vibration isolators, equipment bases, and flexible connections.

1.2 SUMMARY

A. Mount rotating and reciprocating mechanical equipment, ductwork, and piping on vibration isolators as noted in the Contract Documents. Select, install and adjust isolators to prevent the transmission of objectionable vibration and noise to the building structure.

1.3 RELATED WORK

A. Perform vibration isolation work in this Contract, including work described in other Divisions, to meet the product and execution requirements of this Section. Related work includes:

1. Division 1 – General Requirements
2. Division 3 – Concrete
3. Division 4 – Masonry
4. Division 5 – Metals
5. Division 14 – Conveying Equipment
6. Division 22 – Plumbing
7. Division 23 – Heating, Ventilating and Air Condition
8. Division 26 – Electrical
9. Section 018601 – General Acoustic Requirements
10. Section 079219 – Acoustical Sealants
11. Section 220548 – Noise and Vibration Control for Plumbing Systems
12. Section 230549 – Sound Power Level Limits/ Sound Pressure Level Limits
13. Section 260548 – Noise and Vibration Control for Electrical Systems

1.4 QUALITY ASSURANCE

A. Provide all vibration isolators and equipment bases for Division 22, 23 and 26 work from the product line of a single manufacturer, unless otherwise accepted by the Acoustics Consultant.

B. Select isolators to provide uniform deflections within acceptable tolerances when supporting the equipment approved for this project. Coordinate as required with the equipment manufacturers to accomplish this.

C. Provide engineering, isolator selection, site supervision, and inspection by manufacturer's personnel who shall perform these services directly. Alert the Engineer and Acoustics Consultant of isolator selections that may result in resonances with the equipment and structural systems they are intended to isolate. Replace isolators that upon installation are found to resonate with the supported equipment.

D. Provide complete isolation systems that include all elements recommended by the manufacturer for compliance with project requirements and applicable codes, ordinances, and regulations. Include all incidental products and materials required for a complete installation even if not explicitly described in the Construction Documents.

E. Install vibration isolation systems using skilled workers trained and licensed, as applicable, by the manufacturer for installations of the types used on this project. Upon completion of the Work, provide final inspection by the manufacturer's representative and submit to the Architect and Engineer a written report authored by the manufacturer's representative certifying the correctness of installation and compliance with the approved submittal data. Include tabulation of of the static deflection expected under design and operating loads in comparison with the actual static deflection measured in the completed installations.

F. Seismic Restraint Requirements:

1. Design vibration isolation mounts to meet the current design requirements and codes defined by the Structural Engineer. Use appropriate equipment weights and force factors for the equipment used in this project.
2. Provide certification by a licensed professional engineer experienced in the design of restraints for

resiliently mounted equipment, and in the employ of the manufacturer, stating that the requirements of all applicable codes, ordinances and regulations regarding seismic restraint of resiliently mounted equipment have been met by the design. Provide shop drawings, calculations, and analysis stamped by the manufacturer's engineer and demonstrating this compliance.

G. Wind Bracing Requirements:

1. Design vibration isolation mounts to meet the design wind loads defined by the Structural Engineer and required by applicable codes. Provide calculations and certification stating compliance.

1.5 UNACCEPTABLE TYPES

A. Do not used housed spring mounts on this project. Mason models C, CI, and CS; Amber-Booth models Xl and XK; Kinetics SL and SM; and similar mounts are not acceptable.

B. Do not use captive spring mounts on this project. Provide seismic restraint by means of resilient snubbers at the perimeter of the equipment or equipment base and not by mounts that combine isolation and snubbing functions. Mason model SSLFH, Amber-Booth model SWPQ, and similar mounts are not acceptable.

C. Do not use cork as an isolation material.

D. Do not use braided metallic hose for vibration isolation in piping unless fluid temperatures and pressures are beyond the service range of spherical elastomeric isolators.

1.6 STANDARDS

A. American Association of State Highway Transportation Officials (AASHTO) Standard Specifications for Highway Bridges, Highway Bridge Specification, Table B: Requirements for Physical Properties of Bridge-Bearing Quality Neoprene.

1.7 ENGINEERING

A. The Construction Documents are indicative of isolation requirements. Provide complete engineering services for all components of isolation systems used in this project.

1.8 SUBMITTALS

A. Submit manufacturer's data, shop drawings, and product performance certifications in accordance with Division 1.

B. Manufacturer's Data: Submit technical product data confirming that products comply with specified requirements:

1. Illustrations and descriptions of components including, but not limited to isolators, equipment bases, thrust and seismic restraints, anchors, and accessories.

2. Operation and maintenance instructions.

C. Shop Drawings

1. Full-size details of isolation systems, including plan and section drawings indicating isolator and flexible connection locations and types, isolator and connector schedules, details for resilient penetrations, and installation details.

2. Indicate substrate construction required of other subcontractors.

D. Color code legend for spring and elastomer capacities.

E. Samples: provide a sample of each type of isolator assembly used in the project. It is not necessary to submit samples of each spring capacity and pad hardness.

F. Calculations: submit manufacturer's engineer's calculations of loads, deflections, and natural frequencies for record only.

G. Certifications: provide the following:

1. Certification that elastomeric pads meet the requirements of AASHTO Highway Bridge Specification.

H. Supervision plan for manufacturer's representative in the field during installation of vibration isolation systems.

I. General Requirements for Vibration Isolation Mounts and Hangers: Provide catalog cut sheets, shop drawings, and other documents as necessary to describe the installation and its components. Include the following information:

1. Springs:
    a. Equipment name and number
    b. Operating Weight of Equipment
    c. Lowest reciprocating or rotating speed
    d. Isolator type
    e. Weight supported by isolator
    f. Scheduled deflection
    g. Proposed deflection under operating load
    h. Natural Frequency
    i. Spring free height
    j. Spring operating height
    k. Spring solid height at coil bind
    l. Spring diameter
2. Elastomeric Pads:
    a. Equipment name and number
    b. Operating Weight of Equipment
    c. Isolator type
    d. Weight supported by isolator
    e. Pad bearing area
    f. Pad free height
    g. Pad operating height
    h. Scheduled deflection
    i. Proposed deflection under operating load
    j. Percent deflection
    k. Natural Frequency
    l. Hardness and compliance with AASHTO Bridge Bearing Neoprene quality standard

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers listed below have demonstrated an ability to comply with specifications for vibration isolation products similar to those required for this project. However, specific products made by the listed manufacturers do not all comply with the requirements of this specification. Subject to the requirement for a single manufacturer and the restrictions regarding unacceptable types of isolators, the products of the following manufacturers are acceptable sources for this project:
    1. Mason Industries, Inc., Hauppage, New York
    2. Kinetics Noise Control, Dublin, Ohio
    3. Amber-Booth Company, Inc., Houston, Texas
    4. E.A.R., Indianapolis, Indiana
    5. PSI-Thunderline/Link-Seal, Houston, Texas
    6. Ductmate Industries, Inc., East Monongahela, PA
    7. Unger Technologies, Noblesville, IN
    8. RPG Diffusor Systems, Upper Marlboro, MD
    9. DynAir Inc., Lachine, QB
    10. Carlisle Hardcast, Wylie, TX
    11. Acoustical Solutions, Richmond, VA

2.2 SPRING REQUIREMENTS

A. Provide steel springs with static deflections equal to or greater than those shown on the Construction Documents. Submittals based on rated deflections will be rejected.

B. Unless otherwise noted, size springs to provide a natural frequency of not more than 3 Hertz. Where spring deflections called out in the Construction Documents exceed those required to achieve a natural frequency of 3 Hz or less, the greater deflection will govern.

C. Size springs to provide not less than 50 percent additional travel to solid, coil-bind condition beyond the deflection under operating load.

D. Size springs so that diameter is not less than 80 percent of the height of the spring at operating load.

E. Provide springs that do not permanently deflect after loading to a solid, coil-bind condition.

F. Do not weld springs to other components of the isolator assembly unless specifically noted in the Submittals and accepted by the Acoustics Consultant.

G. Color code springs to allow positive identification after installation. Match color coding to the color code legend provided with the submittals.

2.3 ELASTOMER REQUIREMENTS

A. Provide elastomeric elements with static deflections equal to or greater than those shown on the Construction Documents. Submittals based on rated deflections will be rejected.

B. Provide neoprene elements with a maximum hardness of 40 durometer, Shore A rating, where possible, but in no case exceeding 50 durometer. Where deflections called out in the construction documents exceed those required to achieve the specified natural frequencies, the greater deflection will govern.

C. Meet AASHTO Highway Bridge Specifications for all neoprene products installed in irretrievable locations and as required elsewhere in the Construction Documents.

2.4 CORROSION RESISTANCE

A. Treat isolators and associated hardware for resistance to corrosion to the following requirements:

1. Interior exposure:
    a. Steel isolator components: PVC coating or phosphate treatment with finish coat of industrial grade enamel paint.
    b. Structural steel bases and associated components: Cleaned of welding slag, primed with zinc chromate primer (steel) or metal etching primer (aluminum); industrial grade enamel finish coat.
    c. Nuts, bolts, and other fasteners: zinc electroplate with etching primer and enamel paint finish coat.
2. Exterior exposure:
    a. Steel components: PVC coating; or hot-dipped or electroplated zinc with neoprene or bitumastic finish coat.
    b. Aluminum components: etched and painted with industrial grade enamel paint.
    c. Nuts, bolts, and other fasteners: zinc electroplate with etching primer and enamel paint finish coat.

2.5 ACCEPTABLE PRODUCTS

A. (Type H-1) Elastomeric Pads: 5/16-inch minimum thickness, waffled or ribbed neoprene. Where multiple layers are required to provide the specified deflections, interleave pads with 16 gauge steel shim plates. Size pads for deflection equal to 10 to 15 percent of unloaded height and provide pads of sufficient thickness to achieve the specified deflection. Provide load-distributing top plates if required for uniform loading. Acceptable products include

1. Individual pads
    a. Mason W, SW, and Super W
    b. Kinetics NP
    c. Amber-Booth NR
2. Neoprene/Steel composite pads:
    a. Mason WSW
    b. Amber-Booth SP-NR Style E
    c. RPG Custom Elastometic/Steel Composite Pads

B. (Type H-2) Neoprene Base Mount Isolators: Provide double-deflection in-shear isolators with steel bottom plates with pre-drilled bolt holes for attachment to floor or base, a threaded steel insert at the top of the isolator for attaching the equipment, and friction surfaces at both top and bottom. Coat all metal surfaces with neoprene. Design isolators for 0.25 to 0.35 inches of deflection. Acceptable products include:

1. Neoprene-In-Shear Isolators:

a. Mason ND
b. Kinetics RD
c. Amber-Booth RVD

C. (Type H-3) Neoprene Wall Mount Isolators: Solid neoprene or neoprene housed in steel casing. Provide threaded insert to receive equipment mounting bolt. Select isolators of not greater than 50 durometer Shoe A hardness to provide a minimum of .10 inch static deflection in shear-mounting condition under operating load. Acceptable products include:

1. Neoprene Wall-Mount Isolators:

a. Mason BR, RBA, and RCA
b. Kinetics RQ
c. RPG Custom Neoprene Wall Mount Isolator

D. (Type H-4) Elastomeric Hangers: Provide neoprene-in-shear element mounted in a rigid steel hanger box. Mold neoprene element with a rod isolation bushing that prevents rigid contact between hanger rod and housing from vertical through an angular deflection of not less than 30 degrees in any direction. Design for .25 to .35 inch minimum static deflection at rated load. For ductwork hung by straps, provide hangers with eyes on the top and bottom to allow for bolting to the straps. Acceptable products include:

1. Elastomeric Hangers:

a. Mason HD and WHD
b. Kinetics RH
c. Amber-Booth BRD

E. (Type H-5) Open Spring Base-Mounted Isolators: Provide isolators of the general characteristics described in paragraph 2.2, above, that are freestanding and laterally stable with no housing and that are furnished with level-adjustment bolts for rigid connection to the isolated equipment. Provide with molded neoprene cup or 1/4 inch thick Type H-1 elastomeric friction pad between isolator baseplate and its support. Size the pads and associated load distribution plates for deflection of 10 to 20 percent of the unloaded thickness of the pads. Vary spring size as required for equal deflection under non-uniformly distributed equipment loads. Acceptable products include:

1. Open Spring Isolators:

a. Mason SLF
b. Kinetics FDS
c. Amber-Booth SW

F. (Type H-6) Restrained Open Spring Base-Mounted Isolators: Provide built-in adjustable spring restraints for equipment with operating weight greater than weight upon installation to prevent equipment from deflecting (or rising) when the additional weight is applied (or removed in the future). Provide isolators as specified for Type H-5 but with restraint studs and adjustable nuts. Provide ½ inch minimum clearance around the restraint studs. Use bridge-bearing quality neoprene for elastomeric friction pads at chillers and cooling towers. Acceptable products include:

1. Restrained Base Mounted Isolators:

a. Mason SLR
b. Kinetics FLS
c. Amber-Booth CT

G. (Type H-7) Spring Hangers: Provide spring of the general characteristics specified in Paragraph 2.2, above in a rigid steel hanger box. Seat spring in a molded neoprene cup with steel washer reinforcing. Mold neoprene element with a rod isolation bushing that prevents rigid contact between hanger rod and housing from vertical through an angular deflection of not less than 15 degrees in any direction. For ductwork hung by straps, provide hangers with eyes on the top and bottom to allow for bolting to the straps. Acceptable products include:

1. Spring hangers:

a. Mason types 30 and W30
b. Kinetics Type SH
c. Amber Booth type BSA

H. (Type H-8) Spring/Elastomer-in-Series Hangers: Provide neoprene-in-shear element of 1¼-inch minimum

thickness and a spring of the general characteristics specified in Paragraph 2.2, above. Seat spring in a molded neoprene cup with steel washer reinforcing. Mold neoprene element with a rod isolation bushing that prevents rigid contact between hanger rod and housing from vertical through an angular deflection of not less than 15 degrees in any direction. Design neoprene for .25 to .35 inch minimum static deflection at rated load. Do not directly stack the pring and neoprene isolator elements. For ductwork hung by straps, provide hangers with eyes on the top and bottom to allow for bolting to the straps. Acceptable products include:

1. Spring/Elastomer-in-Series Hangers:
    a. Mason 30N
    b. Kinetics SRH
    c. Amber-Booth BSRA

I. (Type H-9) Pre-compressed Spring/Elastomer-in-Series Hangers: Provide built-in adjustable spring restraints for equipment with operating weight greater than weight upon installation to prevent equipment from deflecting (or rising) when the additional weight is applied (or removed in the future). Provide isolators similar to Type H-8, but pre-compressed with restraint mechanisms that can be released to free the spring when subjected to its operational load. Provide an integral scale to indicate amount of deflection. For ductwork hung by straps, provide hangers with eyes on the top and bottom to allow for bolting to the straps. Acceptable products include:

1. Pre-compressed Spring/Elastomer-in-Series Hangers:
    a. Mason PC30N
    b. Kinetics SRH, with restraints
    c. Amber-Booth PBSRA

J. (Type H-10) Thrust Restraints: When total air or fluid thrust exceeds 10 percent of the isolated weight, provide resilient horizontal thrust restraints to prevent excessive horizontal movement. Provide spring isolators similar to Type H-7 with the same deflection as the isolator springs. Preset thrust restraint isolators in the factory and fine tune in the field to allow for a maximum of ¼ inch deflection between at-rest and maximum-thrust conditions. Furnish with appropriate brackets to attach to equipment and the structure. Install restraints on centerline of thrust and symmetrically on both sides of the equipment. Acceptable products include:

1. Thrust Restraints:
    a. Mason WB
    b. Kinetics HSR
    c. RPG Custom Thrust Restraint

K. (Type H-11) Sway Braces: When suspended equipment is subjected to wind loads and other lateral forces not due to thrust, provide isolators similar to Type H-10.

L. (Type H-12) Concrete Inertia Bases: Provide inertia bases of normal weight concrete (150 pcf) and appropriate steel reinforcing within perimeter frames of steel channel, in a rigid assembly that will not twist, deform, deflect, or crack in any manner that would affect the operation of the isolated equipment or the performance of the isolators. Size inertia bases to support equipment housings, motors, and associated pipe and duct elbows, electrical control elements, and any other related components requiring resilient support because of its location on the equipment side of the flexible connections to distribution ductwork and piping. Supply steel frame under this specifications section. Provide concrete under this section or Division 3.

1. Inertia Base sizing requirements: Provide bases with minimum thickness of 6 inches. Increase thickness as required to achieve required mass. Size perimeter steel to be not less than one twelfth of the longest dimension of the base. Space isolators not more than ten times the slab thickness apart. Provide a minimum of 2 inches clearance between floor or housekeeping pad and underside of slab. Use height-saving brackets if required to maintain equipment clearances. Acceptable products include:
    a. Mason types K and BMK
    b. Kinetics Type CIB
    c. RPG Custom Intertia Base

M. (Type H-13) Flexible Neoprene Piping Connectors: Provide flanged twin-sphere or threaded single-sphere isolators with Kevlar cord and peroxide-cured EPDM body with steel rings embedded in flanges to prevent

pull-out. Connectors must accept elongation, compression, axial, and transverse motion. Select materials to suit system temperature, pressure, and fluid type. Do not use control rods or cables to limit extension of the isolator. Use twin-sphere isolators for pipes 2 inches to 14 inches in diameter. Single-sphere isolators may be used for pipes less than 2 inches and greater than 14 inches in diameter. Straight-wall flexible connectors are not acceptable except for sewage ejector pumps. Acceptable products include:

1. Flexible Neoprene Piping Connectors:
    a. Mason types SFDEJ, SFDCR, and SFU
    b. Kinetics Type FTC
    c. Amber Booth Type 2600

N. (Type H-14) Elastomeric Isolators for Mounting Bolts: Provide neoprene grommets, bushings, and washers for all bolts used to secure isolators to floors and housekeeping slabs and for all snubbers. Size bolt holes and washers to accommodate grommets, sleeves, and bushings and to preclude contact between rigid components that would cause bridging between isolated elements and the building structure. Baseplates for neoprene pads may be rigidly bolted to the floor or housekeeping slab if the bolts secure the baseplates only and do not continue through the neoprene to meet any other rigid material. Do not exceed 40 durometer, Shore A hardness. Acceptable products include:

1. Grommets, Washers and Bushings:
    a. Mason HG, HLB and HLW
    b. E.A.R. Isodamp and C-1000
    c. Amber Booth Elastomeric Grommet Isolators

O. (Type H-18) Isolation Roof Curbs: Provide vibration isolation bases for curb-mounted rooftop equipment. Base assemblies must provide a natural frequency of 3 Hertz or below. Provide laterally-stable springs as otherwise specified in paragraph 2.2 and bearing on ¼ inch neoprene pads. Provide resilient snubbers not less than ¼ inch thick to limit lateral deflection under wind loads. Flashing required to shed water may not affect the performance of the isolation system under any combination of design loads. Use flexible EPDM membrane for closure between isolation base and fixed curb. Acceptable products include:

1. Isolation Roof Curbs:
    a. Mason RSC
    b. Kinetics KSR
    c. Thybar Vibro-Curb III

P. (Type H-19) Captive Neoprene Wall Mount Isolators: Provide isolators similar in character to isolators specified in Type H-4. Acceptable products include:

1. Mason types RBA and RCA
2. Kinetics RQ
3. RPG Custom Captive Neoprene Wall Mount Isolator

Q. (Type H-20) Flexible Duct Connections: Provide Hypalon-coated, woven fiberglass, flameproof fabric (24 oz per square yard), serviceable from -40°F to 250°F. Acceptable products include:

1. Ductmate Pro-Flex
2. Dyn-Air Connector-Plus
3. Carlisle Hardcast Hypalon

R. (Type H-21) Flexible Braided Stainless Steel Pipe Connectors: Use only where neoprene single- or double-sphere connectors are not capable of service due to operating temperature or pressure. Provide carbon steel flanges for pipes greater than 3 inches diameter. Male nipples are acceptable for pipe diameters smaller than 3 inches. Acceptable products include:

1. Mason FFL and MN
2. Kinetics Kinflex BFMC
3. Amber Booth Type SS

S. (Type H-22) Mass Loaded Vinyl: Provide mass loaded vinyl of 1 psf surface weight with fiberglass mesh reinforcing with minimum operating temperature range of -40 degrees Fahrenheit to 180 degrees Fahrenheit, resistance to water, oil, fungi, weak acids and alkalies, and transmission loss values of not less than:

125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	STC
15	19	21	28	33	37	26

T. Provide compatible insulation and joint tape as recommended by manufacturer. Acceptable products include:
   1. Kinetics KNM-100RB
   2. Unger UN-10R
   3. Acoustical Solutions AudioSeal AB10R

PART 3- EXECUTION

3.1 GENERAL

A. Before commencing installation examine the substrate and surrounding conditions to insure that there is nothing to prevent proper and timely execution of the installation. Beginning work specified in this Section indicates acceptance of the substrate and surrounding conditions.

B. Install isolation systems in strict compliance with manufacturer's recommendations and engineering, and submittal data. Make no rigid connections to structure that would compromise the performance of the isolation systems.

C. Resiliently mount or hang mechanical equipment, ductwork, piping, and other equipment on structural components indicated on the Drawings and as specified in this section.

D. For all isolated equipment, make connections of piping, ductwork, and conduit using flexible connections specified in this section. Make no connections to isolated equipment in a manner that would compromise the performance of the isolation systems. Refer to Section 230548 – Noise and Vibration Control for Electrical Systems for requirements related to isolation of electrical equipment and connections.

E. Install seismic restraints and sway bracing in conformance with the engineered shop drawings and applicable codes, ordinances, and regulations.

F. Establish isolator locations for ease of installation, adjustment, and inspection as well as specified performance.

G. Replace isolators found to resonate with building structure, at no additional cost to the Owner.

3.2 GENERAL REQUIREMENTS FOR MOUNTS AND HANGERS

A. Align mounts and hangers squarely above or below the equipment mounting holes to avoid introducing lateral loads and deflection.

B. Deflection requirements:
   1. Verify installed isolators have deflections equal to or greater than deflections specified on the submittals.
   2. Where multiple deflections apply to a single isolator (where a single isolator supports multiple isolated elements), the largest deflection governs.
   3. Vary the size and/or hardness of isolators as required to yield equal deflection for all isolators supporting a single piece of equipment or length of pipe or ductwork. Consult manufacturer for direction when specified isolators do not yield required deflection and correct non-compliant isolators at no cost to the Owner.

C. Support equipment, ductwork, conduit and piping independently. Do not hang equipment, ductwork, piping, or conduit from other isolated equipment, ductwork, piping, or conduit.

D. Maintain 2 inches of clearance between isolated elements and walls, ceilings, and other non-isolated building components.

E. Isolate drain piping attached to vibration isolated equipment from rigid components of the building.

F. Limit stops must be inactive and out of contact with the isolator during equipment operation.

G. Adjust leveling bolts and hanger rod lengths so that equipment is level and in alignment with connecting ductwork and piping.

H. Restrained isolators may be substituted for unrestrained isolators at installer's option to simplify installation.

I. Isolate hanger rods passing through barrier ceilings with elastomeric sleeves or grommets or treat as resilient penetrations in accordance with the details and Section 079219 – Acoustical Sealants. Unless noted otherwise, locate equipment, piping, and ductwork below barrier ceilings.

3.3 EQUIPMENT MOUNTED ON FLOORS, HOUSEKEEPING PADS, AND STRUCTURAL ELEMENTS

A. Do not rigidly mount any equipment having rotating or reciprocating components, including air handling unit housings within which fans are spring-isolated. Provide ¾-inch neoprene waffle pads beneath equipment installed on floors and housekeeping slabs without curbs or equipment bases.

B. For equipment with bases, locate isolators on the sides of the base that are parallel to the equipment shaft.

C. At housekeeping slabs and pedestals, position isolators with entire bearing plate on slab or pedestal. Do not cantilever baseplates beyond edges of slabs and pedestals. Coordinate isolator locations with housekeeping slabs so that outboard height-saving mounts do not contact the housekeeping slabs. Notify contractor of work by others requiring remediation for proper installation of isolators.

D. For floor-mounted equipment, provide a minimum of 2 inches operating clearance from the lowest point of the base to the floor or housekeeping slab. Verify that 2 inches of unobstructed clearance has been provided in the final installation under operating loads. Correct nonconforming conditions at no cost to the Owner. Provide height-saving brackets as required to maintain required equipment clearances.

E. For concrete inertia bases, set steel perimeter on bond breaker material, provide steel reinforcing in compliance with Manufacturer's recommendations, and pour normal weight concrete to the full depth of the perimeter steel. If no reinforcing is specified, provide ½-inch reinforcing bar at 6-inch centers each way, and weld reinforcing to the perimeter steel 1½ inches above the bottom of the steel. Provide required anchor bolts held in position by steel templates during the pour.

F. Air Handling Units and Centrifugal Fans (except independent smoke evacuation and stair pressurization fans):

1. Mount on Type H-5 or H-6 open spring base-mounted isolators.
2. Where units are provided with internal structural frames, and external lugs are of sufficient strength and rigidity, mount isolators directly to unit. Otherwise, provide suitable steel bases to maintain housing stability and bearing alignment.
3. On units with internal isolation accepted by the Acoustics Consultant, provide ¾ inch Type H-1 neoprene waffle pads between the unit or base and the floor or housekeeping slab. Use multiple layers separated by steel plates if required to achieve appropriate deflection.
4. For air handling units supported by load-bearing sleepers, provide Type H-1 neoprene pads with steel load-distribution plates as engineered by the isolator manufacturer.
5. Provide Type H-14 sleeves, bushings, grommets, and washers as recommended by the isolator manufacturer to hold isolators in place while preventing rigid short-circuits of the isolation system.
6. Install thrust restraints and sway bracing, specified elsewhere in this section, in accordance with isolator manufacturer's recommendations to prevent rigid short-circuits of the isolation system.
7. Secure piping, conduits, and ductwork with flexible and resilient connections specified elsewhere in this section and in Section 260548 – Noise and Vibration Control for Electrical Systems.

G. Package Air Handling and Air Conditioning Equipment:

1. Do not use package air handling units and package air conditioning units with factory-supplied vibration isolation together with external vibration isolation specified in this section without approval by the isolator manufacturer's engineer. Unless directed otherwise by the isolator manufacturer's engineer, rigidly bolt internally isolated equipment by tightening shipping bolts or by other means.
2. For package units with internal isolation approved by the isolator manufacturer's engineer, provide ¾ inch Type H-2 neoprene isolators between the unit or base and the floor, housekeeping slab, or curb.
3. For air handling units supported by load-bearing sleepers, provide Type H-2 neoprene pads with steel load-distribution plates as engineered by the isolator manufacturer.
4. Provide Type H-14 sleeves, bushings, grommets, and washers as recommended by the isolator manufacturer to hold isolators in place while preventing rigid short-circuits of the isolation system.
5. Install thrust restraints and sway bracing, specified elsewhere in this section, in accordance with

isolator manufacturer's recommendations to prevent rigid short-circuits of the isolation system.

6. Secure piping, conduits, and ductwork with flexible and resilient connections specified elsewhere in this section and in Section 260548 – Noise and Vibration Control for Electrical Systems.

H. Chillers

1. Resiliently support chillers on concrete slabs on grade with Type H-1 multiple layer bridge-bearing neoprene pads sized for not less than .25 inches static deflection. Provide steel top plates of adequate size and thickness to evenly distribute the load on each isolator.
2. Provide Type H-14 sleeves, bushings, grommets, and washers as recommended by the isolator manufacturer to hold isolators in place while preventing rigid short-circuits of the isolation system.
3. Install thrust restraints and sway bracing, specified elsewhere in this section, in accordance with isolator manufacturer's recommendations to prevent rigid short-circuits of the isolation system.
4. Secure piping, conduits, and ductwork with flexible and resilient connections specified elsewhere in this section and in Section 260548 – Noise and Vibration Control for Electrical Systems.

I. Boilers:

1. Provide Type H-1 isolators in multiple layers as required to achieve not less than .25 inch static deflection.
2. Provide Type H-14 sleeves, bushings, grommets, and washers as recommended by the isolator manufacturer to hold isolators in place while preventing rigid short-circuits of the isolation system.
3. Secure piping and conduits with resilient connections specified elsewhere in this section and in Section 260548 – Noise and Vibration Control for Electrical Systems.
4. Treat breeching and flues as isolated ductwork for their entire lengths, including roof penetrations.

J. Floor-Mounted Fan Coil Units:

1. Mount on Type H-2 neoprene pads sized for not less than .25 inch static deflection. Install using Type H-14 bolt connections.
2. Secure piping, ductwork, and conduits with resilient connections specified elsewhere in this section and in Section 260548 – Noise and Vibration Control for Electrical Systems.

K. Elevator Equipment:

1. Mount hydraulic pumps and oil storage tanks on Type H-1 multi-layer bridge-bearing neoprene pads or Type H-2 neoprene base mount isolators. Size isolators for not less than .25 inch static deflection.
2. Connect hydraulic lines using braided stainless steel hose installed parallel to the equipment drive shafts. Provide hose length not less than 20 times its diameter.
3. Isolate entire length of hydraulic lines from the building structure using Type H-1 bridge-bearing neoprene pads.
4. Provide flexible conduit connections as specified in Section 260548 – Noise and Vibration Control for Electrical Systems.

L. Air Compressors:

1. Bolt air compressors to Type H-12 concrete inertia bases with Type H-6 restrained open spring isolators with ¼ inch layer of Type H-1 neoprene pads separated from the isolator friction pad by a 16 gauge steel shim plate. Use Type H-14 bolt isolation for all fasteners to the structure.
2. Install Type H-21 flexible connection on equipment side of shut-off valve. Provide flexible connection length 20 times its diameter and position parallel to equipment drive shaft.
3. Provide flexible electrical connections as specified in Section 260548 – Noise and Vibration Control for Electrical Systems.
4. For split systems, support compressor units as specified above. Mount evaporator section on Type H-2 neoprene base mount isolators.
5. For split systems with rooftop condensing units, mount condensing units on Type H-2 neoprene base mount isolators. Provide flexible connections as specified above.

3.4 ROOFTOP VIBRATION ISOLATION CURBS

A. Rooftop fans:

1. For all rooftop fans, including toilet exhaust fans, provide Type H-1 neoprene pads sized for 10 to 15 percent deflection between the fan base and the fixed curb. Allow no rigid components to short-circuit the isolators.
2. Provide Type H-14 sleeves, bushings, grommets, and washers as recommended by the isolator manufacturer to hold isolators in place while preventing rigid short-circuits of the isolation system.
3. Install thrust restraints and sway bracing, specified elsewhere in this section, in accordance with isolator manufacturer's recommendations to prevent rigid short-circuits of the isolation system.
4. Secure piping, conduits, and ductwork with flexible and resilient connections specified elsewhere in this section and in Section 260548 – Noise and Vibration Control for Electrical Systems.

3.5 SUSPENDED EQUIPMENT

A. Centrifugal Fans, Axial Fans, and Fan Coil Units

1. Resiliently hang fans and fan coil units with Type H-8 spring/elastomer-in-series isolators.
2. Connect ductwork with Type H-20 flexible duct connections at inlet and discharge. Connect fan coil piping with Type P-13 flexible piping connectors from Section 220548 – Noise and Vibration Control for Plumbing Systems.
3. Provide flexible electrical connections as specified in Section 260548 – Noise and Vibration Control for Electrical Systems.

3.6 PIPING AND CONDUIT ISOLATION

A. Isolate all piping 1½ inches and larger in diameter that is connected to rotating or reciprocating equipment. Waste, vent, rainwater, and fire protection piping do not require isolation unless noted otherwise.

B. Select and install isolators in a manner that does not induce stresses in piping connections and does not result in misalignment of shafts and bearings. Maintain equipment and piping in rigid condition during installation. Do not transfer loads to the isolators until the installation is complete and under full operational load.

C. Isolator Types:

1. For equipment isolated with supports and mounts containing springs, provide Type H-8 or H-9 spring/elastomer-in-series isolators for the first 4 horizontal piping hangers and associated vertical piping. Size these hangers to provide the same static deflection as the isolators for the equipment. For floor-supported piping, use Type H-6 open spring base mount isolators and Type H-2 neoprene base mount isolators.
2. Beyond the 4 hangers nearest the equipment, within the rooms housing the equipment and for a distance of not less than 50 feet from the equipment, provide Type H-7 elastomeric hangers, and provide Type H-7 hangers for all piping of 2-inch and smaller diameter and flow rates of greater than 4 feet per second.
3. For pipes larger than 2-inch and not greater than 6-inch diameter throughout the building, support entire length on Type H-7 elastomeric hangers, Type H-2 neoprene base mount isolators, or Type H-1 elastomeric pads between the piping and all points of contact between piping and non-isolated construction.
4. For pipes larger than 6-inch diameter, support entire length throughout the building on Type H-9 restrained spring/elastomer-in-series hangers, or Type H-6 restrained spring/elastomer-in-series base mounts if supported from the floor.
5. For all piping hung from construction beneath Acoustically Sensitive and Acoustically Critical Rooms as defined in Section 018601 – General Acoustic Requirements, provide Type H-8 spring/elastomer-in-series isolators with minimum deflections as follows:
    a. Pipe diameters up to and including 3 inches: ¾-inch deflection.
    b. Pipe diameters larger than 3 inches up to and including 6 inches: 1½-inch deflection.
    c. Pipe diameters larger than 6 inches: 2½-inch deflection.
6. Vertical Piping:
    a. Support vertical piping 2-inch diameter and larger on Type H-6 restrained spring/elastomer-in-series base mounts for the first 3 support points nearest the equipment.
    b. Support all other vertical piping of 2-inch and smaller diameter within 50 feet of connected

equipment on Type H-2 neoprene base mount isolators.

c. For vertical pipes larger than 2-inch diameter and not greater than 6-inch diameter throughout the building, support on Type H-2 neoprene base mounts.

d. Support all vertical piping greater than 6-inch diameter throughout the building on Type H-6 restrained spring/elastomer-in-series base mounts.

D. Position isolators as high as possible in the hanger rod or strap assembly but not in direct contact with the building structure without manufacturer's written authorization. Provide 1 inch minimum clearance between isolator housing and structure above. Provide side clearance for hangers to allow full 360-degree rotation about the rod axis without contacting any object.

E. Parallel pipes can be hung together on a trapeze that is isolated from the structure. Isolator deflections must be equal to or greater than the greatest deflection required for the pipes if isolated individually. Do not mix isolated and non-isolated piping on the same trapeze.

F. Mount flexible connections for piping to equipment on the equipment side of shut-off valves.

G. Provide isolation of expansion tanks, air separators, and other devices similar to that provided for the attached piping.

3.7 DUCTWORK ISOLATION

A. Connect ductwork to equipment, including heat pumps, using Type H-20 flexible duct connections. Crimp fabric into duct flanges and seal airtight. Provide minimum separation of 2 inches between duct and equipment. Provide 1½ inch minimum slack or as required to accommodate full range of equipment and duct movement when subjected to maximum operating and lateral loads simultaneously without becoming taut. Utilize Type H-10 thrust restraints to limit horizontal movement so that flexible connections do not become taut under any combination of operational loads. Mount flexible duct connections as close to equipment housings as practical but in no case beyond the first duct hanger.

B. Duct Connections at Rigidly-Mounted Fire Dampers: Provide Type H-20 flexible duct connections at each side of all fire dampers rigidly connected to the associated partition construction.

C. Isolator Types:

1. Provide Type H-8 spring/elastomer-in-series hangers for the first 3 duct hangers from Air Handling Units and Fans. Ductwork connecting to Heat Pumps does not require isolation beyond the H-20 flexible connections. Provide hangers with minimum static deflection equal to that of the isolators supporting the equipment.

2. Beyond the first 3 hangers, support all ductwork with short-side dimension less than 24 inches in the following manner:

a. Support with Type H-7 elastomeric hangers, Type H-2 neoprene base mounts, or Type H-1 elastomeric pads at all points of support within 50 feet of the equipment to which the ductwork connects.

b. Beyond 50 feet from the equipment, no isolation is required.

3. Beyond the first 3 hangers, support ductwork with short-side dimension of 24 inches or greater in the following manner:

a. Support with Type H-9 pre-compressed spring/elastomer-in-series hangers or Type H-4 restrained open spring base mount isolators for a minimum of 50 feet from the equipment.

4. Vertical Ductwork:

a. Support vertical ductwork for the 3 supports nearest the equipment with Type H-6 open mount spring isolators with minimum deflections equal to or greater than the isolators supporting the equipment.

b. Thereafter, support all vertical ductwork with short-side dimension less than 24 inches with Type H-2 neoprene base mount isolators for not less than 50 feet from the equipment.

c. Support all vertical ductwork with short-side dimension equal to or greater than 24 inches and all other ductwork indicated on the Drawings to receive isolation on Type H-6 open spring base mount isolators.

3.8 THRUST RESTRAINTS

A. Protect pumps and air handling equipment from excessive deflection with appropriate thrust restraints. Protect roof mounted equipment from lateral deflection due to wind loads using snubbers and sway

bracing. All bracing and restraints must be engineered by the manufacturer and included in the submittals.

3.9 PENETRATIONS OF STRUCTURE, PARTITIONS, AND CEILINGS

A. Provide resilient penetration seals for all HVAC penetrations of walls floors, and ceilings of equipment rooms, all rooms classified as Acoustically Critical and Acoustically Sensitive in Section 018601 – General Acoustic Requirements and elsewhere as required by the Construction Documents. Provide the following:

1. 22 gage steel sleeve grouted rigidly in place in all wall, floor, and ceiling locations; except that sleeves may be omitted at properly sized cored or sleeved penetrations through solid concrete, solid or grouted masonry walls. And hollow partitions in which solid blocking has been placed for coring of penetrations. Size sleeves and cored holes to provide annular space of ½ to ¾ inch width around conduit. Center the conduit in the sleeve or penetration.

2. Pack the annular space with lose glass- or mineral-fiber insulation to the full depth of the wall or floor/ceiling construction. Seal completely between sleeve and conduit with Acoustical Sealant installed in accordance with Section 079219 – Acoustical Sealant.

3.10 MASS LOADED VINYL

A. Wrap designated piping, ductwork, and other elements with mass loaded vinyl installed over insulation in accordance with manufacturer's recommendations.

B. For piping and ductwork with risk of condensation within the external insulation, spray-apply vapor absorber to the outside of the element before installing insulation or utilize polyethylene sheet as a vapor barrier.

C. Install glass fiber, mineral fiber or polyurethane foam insulation of 1 ½ pcf to 3 pcf density around the outside of the element. Use insulation compatible with required fire ratings. Use 1-inch thick insulation for piping of 3 inch and smaller diameter and ductwork of 144 square inches or less in free area. Use 2-inch insulation for larger piping and ductwork.

D. Wrap each element individually and continuously on all sides with a minimum overlap of 2 inches at seams. Tape all seams airtight using tape recommended by the loaded vinyl manufacturer. Do not use duct tape for this purpose. If clearance above the element to the underside of the structural deck does not permit installation of the vinyl between the element and the deck, request direction for the Acoustics Consultant.

E. Install a second layer of the loaded vinyl for areas so indicated and where a single layer fails to meet the Noise Criteria defined in Section 018601 – General Acoustical Requirements. Stagger seams not less than 12 inches from those of the first layer and tape as described above.

F. All layers of loaded vinyl must extend for the full length of piping and ductwork scheduled for loaded vinyl wrap, including elbows, branches, and terminal devices such as roof drains. Tape and seal the ends of the installation to perimeter walls and slabs.

G. Cut in access flaps for valves, access panels, and other items requiring access. Tape edges of access flaps and indelibly label each flap for its purpose.

3.11 TESTING, EVALUATION AND ACCEPTANCE PROCEDURES

A. If it is found that the construction fails the acoustic test measurements or performance requirements identified in the Contract Documents, make changes necessary to meet the requirements identified in the Contract Documents and be responsible for the costs associated with performing all additional acoustical tests to verify the acoustic performance of the construction. Costs for additional acoustical testing shall include consulting fees at per hour rates in effect at the time of testing along with related expenses including, but not limited to, travel expenses and test equipment use charges.

END OF SECTION

SOUND PRESSURE / SOUND POWER LEVEL LIMITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Sound power Level and Sound Pressure Level limits for Air Handling Units and Heat Pumps.

1.2 SUMMARY

A. Provide equipment that meets the sound power limits established in this section.

1.3 RELATED WORK

A. Perform vibration isolation work in this Contract, including work described in other Divisions, to meet the product and execution requirements of this Section. Related work includes:

1. Division 22 – Plumbing
2. Division 23 – Heating, Ventilating and Air Conditioning
3. Division 26 – Electrical
4. Section 230548 – Noise and Vibration Control in HVAC Systems
5. Section 260548 – Noise and Vibration Control in Electrical Systems

1.4 STANDARDS

A. Base submitted sound power levels upon laboratory test data taken in compliance with AMCA Standard 300; Reverberant Room Method for Sound Testing of Fans, 1985.

B. Inlet and Discharge sound pressure levels for ducted fans may be taken in accordance with ASHRAE Standard 68 (AMCA 300); Laboratory Method of Testing In-Duct Sound Power Measurement Procedure for Fans, 1986.

C. Conduct tests in an AMCA-certified acoustics testing laboratory.

D. For sound power level data development, comply with AMCA Standard 301; Methods for Calculating Fan Sound Ratings from Laboratory Test Data, 1990.

E. Values based on ASHRAE Handbook estimation method, the Wells plenum calculation, or other estimation methods are not acceptable.

1.5 SUBMITTALS

A. Submit the following information in compliance with Division 1:

1. Sound Power Level data for unit discharge and inlet openings and for casing-radiated noise. Provide values in decibels on the linear (unweighted) scale for octave bands of center frequency from 63 Hertz to 8,000 Hertz. Submit test data for the units to be used on this project or test data for the configurations used to develop the submitted levels when values are interpolated from those taken from tests of similar equipment.
2. Description of the test facility, the test setup, and the number of fans tested to establish the sound power database.
3. Certification that the data were developed in compliance with accepted standards. Described the standards used for the tests and the method of data interpolation (Specific Sound Power Level Method or Generalized Sound Power Spectrum; AMCA 301-90).
4. Certification of the laboratory by AMCA.
5. Fan curve and design point of operation for each fan.

B. Submittals failing to comply with the requirements of this section will be rejected.

1.6 DEFINITIONS

A. 'Unit' is defined as the entire fan-powered device, including casing, plena, integral silencers, and other appurtenances.

B. 'Bare Fan' is defined as a fan that is not integrated into a larger assembly.

1.7 MEASUREMENT REQUIREMENTS

A. Measure inlet and discharge sound power levels at the cabinet inlet and discharge openings based upon the design performance of the supply and return fans to be used in this project. Report levels that include the effects of plena, housings, acoustic linings, and location of opening in the cabinet that corresponds to

that of the equipment for this project. Adjust for end reflection effects for tests measurements taken in ducted inlet and discharge openings.

B. Where mechanical air volume control elements such as inlet vanes and disks are provided as part of the unit cabinet, provide data for volume control device at maximum, minimum, and intermediate point on the system curve.

C. Cabinet-radiated sound power levels must describe total-unit casing-radiated levels.

1.8 GUARANTEE

A. Certify that the submitted units will operate within the specified sound pressure and sound power levels when operated within design parameters. If the units are determined to be operating in excess of the specified levels upon commissioning, correct the condition at no cost to the Owner. Pay related time and materials expenses incurred by the Architect, Design Engineer, and Acoustics Consultant during the evaluation and remedy of non-compliant conditions.

PART 2 - PRODUCTS

2.1 SCHEDULES

A. Do not exceed the following Sound Power Level Limits:

Equipment Tag		Octave Band Center Frequency (Hz)							
		63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
DOA-1	Discharge	100	100	100	100	100	100	100	100
	Inlet	100	100	100	100	100	100	100	100
HP 1-2, 1-3, 1-4, 1-5, 2-3, 2-12, 3-2,	Discharge	52	52	57	62	54	51	52	45
	Free Inlet & Casing Radiated	67	67	59	58	54	53	49	42
HP 1-10, 1-11, 1-14, 2-1, 2-2, 2-5, 2-10, 3-1, 3-6, 3-10, 3-11	Discharge	74	74	62	62	60	60	58	51
	Radiated	72	72	63	60	58	55	52	43
HP 1-1, 1-8, 1-9, 2-7, 3-7, 3-9, B-1	Discharge	79	79	71	66	70	67	66	61
	Casing Radiated	77	77	71	66	64	61	58	51
HP 3-8	Discharge	75	75	64	61	63	61	60	54
	Casing Radiated	78	78	70	63	62	59	56	49
HP 1-6, 2-4	Discharge	76	76	71	67	65	64	63	55
	Casing Radiated	77	77	71	66	64	60	56	48
HP 2-11, 3-3	Discharge	75	75	64	61	63	61	60	54
	Casing Radiated	75	75	66	62	60	59	55	48
HP 2-6, 2-8, 2-9, 3-4	Discharge	71	71	58	56	57	55	55	48
	Casing Radiated	70	70	65	59	57	53	58	42
HP 1-7, 2-13	Discharge	64	64	58	51	51	47	45	40
HP 1-12	Discharge	71	71	59	68	68	63	63	56
HP 1-13, 2-14, 3-5	Discharge	62	62	56	46	46	42	39	35

EF-1	**Inlet**	77	76	73	67	59	58	54	48

PART 3 - EXECUTION

3.1 REMEDIES

A. For units with noise levels in excess of the limits specified in this section, provide attenuators, plena, lining, and other accessories as required to comply with the limits. Submit for review and acceptance by the Architect, Engineer, and Acoustics Consultant prior to implementation.

END OF SECTION

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Valve tags.
6. Warning tags.
7. Sample Schedules.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label. An electronic copy and hard copy will be provided to THE OWNER before preliminary acceptance. Furnish extra copies (in addition to mounted copies) for Maintenance.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals. An electronic copy and hard copy will be provided to the Owner before preliminary acceptance. Furnish extra copies (in addition to mounted copies) for Maintenance.

1.3 QUALITY ASSURANCE

A. Follow manufacturer's recommended installation procedures.

B. As applicable, comply with ASME A13.1 "Scheme for the Identification of Piping System"

1.4 DELIVERY, STORAGE AND HANDLING

A. Store materials in a dry and secure area on-site and protect against dirt and moisture damage

B. Do not apply or install damaged materials.

1.5 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

1.6 WARRANTY

A. Provide warranty on materials and labor for 18 months starting from date of delivery, or one year from date of substantial completion, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following manufacturers:
1. Seton
2. Brady
3. Best
4. Milwaukee

2.2 EQUIPMENT LABELS

A. Metal Labels for Equipment:
1. Material and Thickness: Brass, 0.032-inch or Stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.

2. Minimum Letter Size: 4 by 2 inch. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
3. Fasteners: Stainless-steel self-tapping screws.
4. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data. See Sample Equipment Schedule at end of this Specification.

2.3 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: Yellow.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F .

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch .

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches , 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions. Coordinate with Architect and Owner for specific warning label information to be included.

2.4 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction. Do not provide labels for bare pipes conveying fluids at temperatures of 125 °F or higher.

B. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.5 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black

C. Background Color: White.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F .

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch .

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

2.6 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch or Stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass beaded chain.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Valve-tag schedule shall be included in operation and maintenance data. See Sample Valve Tag Schedule at the end of this Specification.

2.7 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: 4 by 7 inches.
   2. Fasteners: Reinforced grommet and wire.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
   4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09 Section " Painting**"**

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 15 feet in areas of congested piping and equipment.
   7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule:
   1. Chilled-Water Piping:
      a. Background Color: Blue.
      b. Letter Color: Black.
   2. Geothermal and Condenser-Water Piping:
      a. Background Color: Blue.

b. Letter Color: Black.
3. Heating Water Piping:
a. Background Color: Red.
b. Letter Color: Black.
4. Refrigerant Piping:
a. Background Color: White.
b. Letter Color: Black.

D. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts..

E. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.4 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

A. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
1. Valve-Tag Size and Shape:
a. Chilled Water: 2 inches, round.
b. Geothermal and Condenser Water: 2 inches, round..
c. Refrigerant: 2 inches, round..
d. Hot Water: 2 inches, round.
e. Gas: 2 inches, round..
2. Valve-Tag Color:
a. Chilled Water: Natural.
b. Geothermal and Condenser Water: Natural.
c. Refrigerant: Natural.
d. Hot Water: Natural.
e. Gas: Natural.
3. Letter Color:
a. Chilled Water: Black.
b. Geothermal and Condenser Water: Black.
c. Refrigerant: Black.
d. Hot Water: Black.
e. Gas: Black.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

3.7 SAMPLE SCHEDULES

A. The following tables are examples of schedules required to be submitted by the Contractor. Examples of the kinds of information to be included are in the first row in these tables.

CHILLED-WATER, VALVE-TAG SCHEDULE

VALVE NUMBER	VALVE TYPE	VALVE SIZE	VALVE LOCATION	NORMAL OPERATING POSITION	REMARKS
CHWS-1	GATE	NPS 2	MECHANICAL ROOM	OPEN	

			M-1		

EQUIPMENT LABEL SCHEDULE

EQUIPMENT IDENTIFICATION	EQUIPMENT LOCATION	SPECIFICATION SECTION		REMARKS
		NUMBER	TITLE	
AHU-1	MECHANICAL ROOM M-215	23 xx xx		MODULAR INDOOR AIR-HANDLING UNITS

3.8 CLEANING

A. Follow manufacturer's instructions for surface preparation prior to application or installation.

B. Follow Manufacturer's instructions for cleaning labels and tags.

END OF SECTION

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes procedural requirements for testing, adjusting, and balancing (TAB) of new and existing systems to achieve the required flows within the limits of the fan and the motor HP. The testing, adjusting, and balancing work includes producing design objectives for the following:
   1. Air Systems:
      a. Constant-volume air systems.
      b. Variable-air-volume systems.
   2. Hydronic Piping Systems:
      a. Constant-flow systems.
      b. Variable-flow systems.
      c. Primary-secondary systems.
      d. Motors.
      e. Condensing Units.
      f. Heat Transfer Coils.
   3. HVAC equipment quantitative-performance settings.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, Adjusting, and Balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Firm: Entity responsible for performing and reporting TAB procedures.

F. TAB Specialist: Entity engaged by TAB Firm to perform TAB work.

1.3 SUBMITTALS

A. Qualification Data: Within 30 days of Notice to Proceed, submit documentation for the TAB contractor and the Project's TAB team members.

B. Contract Documents Examination Report: Within 30 days of Notice to Proceed, submit the Contract Documents Examination Report.

C. TAB Plan: Within 30 days of Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. Certified TAB reports. Submit two copies of the TAB reports prepared as specified in this specification on approved forms certified by the TAB contractor.

E. LEED Submittal:
   1. Air-Balance Report for LEED Prerequisite EQ 1: Documentation of work performed for ASHRAE 62.1-2007, Section 7.2.2, "Air Balancing."

F. Sample report forms. Submit two copies of the sample TAB report forms

G. Instrument calibration reports, including the following:
   1. Instrument type and make.
   2. Serial number.
   3. Application.
   4. Dates of use.
   5. Dates of calibration.

1.4 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC, NEBB, or TABB.
   1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC, NEBB or TABB.
   2. TAB Technician: Employee of the TAB contractor and who is certified by AABC, NEBB or TABB as a TAB technician.

B. TAB Conference: Prior to the start of the TAB work, and at Contractor's direction, coordinate a meeting at the Site to review the TAB strategies and procedures plan and to develop a mutual understanding of the details of the work involved. The meeting shall include the Architect, the Owner Representative, the Commissioning Authority (CxA), the TAB field supervisor, and the TAB technicians. Provide at least seven days' advance notice of meeting date and time.
   1. Agenda Items:
      a. The Contract Documents examination report.
      b. The TAB plan.
      c. Coordination and cooperation of trades and subcontractors.
      d. Coordination of documentation and communication flow.
      e. Submittal distribution requirements.
      f. Work Schedule and Project-Site requirements.

C. Certification of TAB Reports: Certify TAB field data reports and perform the following:
   1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
   2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard TAB forms from NEBB, AABC or TABB as well as providing any additional information required by this specification.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

F. Owner reserves the right to select at random 10% of the TAB report data for field verification witnessed by the commission agent. The TAB contractor will be given sufficient notice of the date of field verification. The same instruments that were used when the original test was recorded shall be used. A failure of more than 10% of the selected field verification items shall result in a repeat of the testing of the entire system at the TAB contractor's expense. The repeated work is also subject to field verification.

1.5 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.6 WARRANTY

A. Provide warranty in accordance with AABC, NEBB or TABB standards:
   1. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.
   2. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.
   3. Guarantee shall include the following provisions:
      a. The certified TAB firm has tested and balanced systems according to the Contract Documents.
      b. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents and field conditions to become familiar with Project requirements and to discover conditions that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums used for return air to verify that they meet the leakage class of connected ducts as specified in Division 23 Section "Metal Ducts," and are properly separated from adjacent areas. Verify that penetrations in plenum walls are properly sealed or, as required, fire-stopped.

F. Examine equipment performance data including fan and pump curves.
   1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
   2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that screens are clean and proper perforations are provided. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine equipment for installation and properly operating safety interlocks and controls.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB Plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:
   1. Permanent electrical-power wiring is complete.
   2. Hydronic systems are filled, clean, and free of air.
   3. Automatic temperature-control systems are operational.
   4. Equipment and duct access doors are securely closed.
   5. Balance, smoke, and fire dampers are open.
   6. Isolating and balancing valves are open and control valves are operational.
   7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
   8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance," ASHRAE 111, NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing," and this Section.

1. Comply with requirements in ASHRAE 62.1-2007, Section 7.2.2, "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
   1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

E. HVAC system lineup. The contractor will test the system in the normal system lineups.
   1. A hydronic system with two chillers designed to run at the same time, the system will be balanced with pumps flowing to both chillers. All pump data will also be collected when the pump is flowing to only one chiller.
   2. Air systems will be balanced while aligned for minimum outside air flow and the position of the outside air dampers will be recorded for the minimum position.
   3. It s not acceptable to balance air systems when the normal boundaries, doors, walls, or ductwork are not in their design configuration.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer and within the limits of the motor HP. All fans shall deliver the design air flow capacity at actual static pressure up to design static. Fan sheaves shall be replaced as necessary to obtain desired results.
   1. Measure total airflow.
      a. Where sufficient space in ducts is unavailable for Pitot-tube-traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
   2. Measure fan static pressures as follows to determine actual static pressure:
      a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
      b. Measure static pressure directly at the fan outlet or through the flexible connection.
      c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
      d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
   3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, sub-main ducts, and major branch ducts to indicated airflows within specified tolerances.
1. Measure airflow of sub-main and branch ducts.
a. Where sufficient space in sub-main and branch ducts is unavailable for Pitot-tube-traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. Re-measure each sub-main and branch duct after all have been adjusted. Continue to adjust sub-main and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.
1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
1. Minimum outside air flow rate must be verified under three conditions, with the OA damper position recorded in each configuration.
a. System operating with all boxes at minimum primary air flow.
b. System at maximum supply flow (diversity may not allow all boxes to be open).
c. System flow halfway between box minimum and maximum.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.

5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
    a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
6. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
1. Open all manual valves for maximum flow.
2. Check liquid level in expansion tank.
3. Check makeup water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation, and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:
1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
    a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from the Board Authorized Representative and comply with requirements in Division 23 Section "Hydronic Pumps."
2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
    a. Monitor motor performance during procedures and do not operate motors in overload conditions.
3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presets.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.

J. Check settings and operation of each safety valve. Record settings.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first and then balance the secondary circuits.

3.11 PROCEDURES FOR HEAT EXCHANGERS

A. Measure water flow through all circuits.

B. Adjust water flow to within specified tolerances.

C. Measure inlet and outlet water temperatures.

D. Measure inlet steam pressure.

E. Check settings and operation of safety and relief valves. Record settings.

3.12 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.13 PROCEDURES FOR BOILERS

A. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.

B. Steam Boilers: Measure and record entering-water temperature and flow and leaving-steam pressure, temperature, and flow.

3.14 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:
1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.

6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each electric heating coil:
1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:
1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Air pressure drop.
4. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:
1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.15 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. Check main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.16 TOLERANCES

A. Set HVAC system air flow rates and water flow rates within the following tolerances:
1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 5 percent.

3.17 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

3.18 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:
1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:
1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:
    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.

h. Sheave make, size in inches, and bore.
i. Center-to-center dimensions of sheave, and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
3. Test Data (Indicated and Actual Values):
   a. Total air flow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Filter static-pressure differential in inches wg.
   f. Preheat coil static-pressure differential in inches wg.
   g. Cooling coil static-pressure differential in inches wg.
   h. Heating coil static-pressure differential in inches wg.
   i. Outdoor airflow in cfm.
   j. Return airflow in cfm.
   k. Outdoor-air damper position.
   l. Return-air damper position.
   m. Vortex damper position.

F. Apparatus-Coil Test Reports:
1. Coil Data:
   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch.
   f. Make and model number.
   g. Face area in sq. ft.
   h. Tube size in NPS.
   i. Tube and fin materials.
   j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
   a. Air flow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.
   g. Leaving-air, wet- and dry-bulb temperatures in deg F.
   h. Water flow rate in gpm.
   i. Water pressure differential in feet of head or psig.
   j. Entering-water temperature in deg F.
   k. Leaving-water temperature in deg F.
   l. Refrigerant expansion valve and refrigerant types.
   m. Refrigerant suction pressure in psig.
   n. Refrigerant suction temperature in deg F.
   o. Inlet steam pressure in psig.

G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
1. Unit Data:

a. System identification.
b. Location.
c. Coil identification.
d. Capacity in kW
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Air flow rate in cfm.
i. Face area in sq. ft.
j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):
a. Heat output in kW
b. Air flow rate in cfm.
c. Air velocity in fpm.
d. Entering-air temperature in deg F.
e. Leaving-air temperature in deg F.
f. Voltage at each connection.
g. Amperage for each phase.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:
1. Fan Data:
a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. Motor Data:
a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:
a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft.
g. Indicated air flow rate in cfm.
h. Indicated velocity in fpm.
i. Actual air flow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

J. Air-Terminal-Device Reports:
   1. Unit Data:
      a. System and air-handling unit identification.
      b. Location and zone.
      c. Apparatus used for test.
      d. Area served.
      e. Make.
      f. Number from system diagram.
      g. Type and model number.
      h. Size.
      i. Effective area in sq. ft.
   2. Test Data (Indicated and Actual Values):
      a. Air flow rate in cfm
      b. Air velocity in fpm
      c. Preliminary air flow rate as needed in cfm
      d. Preliminary velocity as needed in fpm
      e. Final air flow rate in cfm
      f. Final velocity in fpm
      g. Space temperature in deg F

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
   1. Unit Data:
      a. System and air-handling-unit identification.
      b. Location and zone.
      c. Room or riser served.
      d. Coil make and size.
      e. Flowmeter type.
   2. Test Data (Indicated and Actual Values):
      a. Air flow rate in cfm
      b. Entering-water temperature in deg F.
      c. Leaving-water temperature in deg F.
      d. Water pressure drop in feet of head or psig.
      e. Entering-air temperature in deg F.
      f. Leaving-air temperature in deg F.

L. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
   1. Unit Data:
      a. Unit identification.
      b. Location.
      c. Service.
      d. Make and size.
      e. Model number and serial number.
      f. Fluid flow rate in gpm
      g. Fluid pressure differential in feet of head or psig
      h. Required net positive suction head in feet of head or psig
      i. Pump rpm.
      j. Impeller diameter in inches.
      k. Motor make and frame size.
      l. Motor horsepower and rpm.
      m. Voltage at each connection.
      n. Amperage for each phase.
      o. Full-load amperage and service factor.
      p. Seal type.
   2. Test Data (Indicated and Actual Values): All values measured in a fluid other than water will include the measured value corrected to the equivalent in water.
      a. Static head in feet of head or psig,
      b. Pump shutoff pressure in feet of head or psig.

c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final fluid flow rate in gpm.
j. Voltage, phase to phase.
k. Amperage for each phase.

M. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, or water-cooled condensing units, include the following:
1. Unit Data:
a. Unit identification.
b. Location.
c. Unit make and model number.
d. Compressor make.
e. Compressor model and serial numbers.
f. Refrigerant weight in lb.
g. Low ambient temperature cutoff in deg F.
2. Test Data (Indicated and Actual Values):
a. Inlet-duct static pressure in inches wg.
b. Outlet-duct static pressure in inches wg.
c. Entering-air, dry-bulb temperature in deg F.
d. Leaving-air, dry-bulb temperature in deg F.
e. Condenser entering-water temperature in deg F.
f. Condenser leaving-water temperature in deg F.
g. Condenser-water temperature differential in deg F.
h. Condenser entering-water pressure in feet of head or psig.
i. Condenser leaving-water pressure in feet of head or psig.
j. Condenser-water pressure differential in feet of head or psig.
k. Control settings.
l. Unloader set points.
m. Low-pressure-cutout set point in psig.
n. High-pressure-cutout set point in psig.
o. Suction pressure in psig.
p. Suction temperature in deg F.
q. Condenser refrigerant pressure in psig.
r. Condenser refrigerant temperature in deg F.
s. Oil pressure in psig.
t. Oil temperature in deg F.
u. Voltage at each connection.
v. Amperage for each phase.
w. Kilowatt input.
x. Crankcase heater kilowatt.
y. Number of fans.
z. Condenser fan rpm.
aa. Condenser fan airflow rate in cfm.
bb. Condenser fan motor make, frame size, rpm, and horsepower.
cc. Condenser fan motor voltage at each connection.
dd. Condenser fan motor amperage for each phase.

N. Condenser Test Reports: For condensers, include the following:
1. Unit Data:
a. Unit identification.
b. Make and type.
c. Model and serial numbers.
d. Nominal cooling capacity in tons.

e. Refrigerant type and weight in lb.
f. Water-treatment chemical feeder and chemical.
g. Number and type of fans.
h. Fan motor make, frame size, rpm, and horsepower.
i. Fan motor voltage at each connection.
j. Sheave make, size in inches, and bore.
k. Sheave dimensions, center-to-center, and amount of adjustments in inches.
l. Number of belts, make, and size.
m. Pump make and model number.
n. Pump manufacturer's serial number.
o. Pump motor make and frame size.
p. Pump motor horsepower and rpm.

2. Pump Test Data (Indicated and Actual Values):
   a. Voltage at each connection.
   b. Amperage for each phase.
   c. Water flow rate in gpm.
3. Water Test Data (Indicated and Actual Values):
   a. Entering-water temperature in deg F.
   b. Leaving-water temperature in deg F.
   c. Water temperature differential in deg F.
   d. Entering-water pressure in feet of head or psig.
   e. Leaving-water pressure in feet of head or psig.
   f. Water pressure differential in feet of head or psig.
   g. Water flow rate in gpm.
   h. Bleed water flow rate in gpm.
4. Air Data (Indicated and Actual Values):
   a. Duct airflow rate in cfm.
   b. Inlet-duct static pressure in inches wg.
   c. Outlet-duct static pressure in inches wg.
   d. Average entering-air, wet-bulb temperature in deg F.
   e. Average leaving-air, wet-bulb temperature in deg F.
   f. Ambient wet-bulb temperature in deg F.

O. Heat-Exchanger/Converter Test Reports: For steam and hot-water heat exchangers, include the following:
1. Unit Data:
   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and type.
   e. Model and serial numbers.
   f. Ratings.
2. Primary Water Test Data (Indicated and Actual Values):
   a. Entering-water temperature in deg F.
   b. Leaving-water temperature in deg F.
   c. Entering-water pressure in feet of head or psig.
   d. Water pressure differential in feet of head or psig.
   e. Water flow rate in gpm.
3. Secondary Water Test Data (Indicated and Actual Values):
   a. Entering-water temperature in deg F.
   b. Leaving-water temperature in deg F.
   c. Entering-water pressure in feet of head or psig.
   d. Water pressure differential in feet of head or psig.
   e. Water flow rate in gpm

P. Boiler Test Reports:
1. Unit Data:
   a. Unit identification.
   b. Location.

c. Service.
d. Make and type.
e. Model and serial numbers.
f. Fuel type and input in Btuh.
g. Number of passes.
h. Ignition type.
i. Burner-control types.
j. Voltage at each connection.
k. Amperage for each phase.

2. Test Data (Indicated and Actual Values):
a. Operating pressure in psig.
b. Operating temperature in deg F.
c. Entering-water temperature in deg F.
d. Leaving-water temperature in deg F.
e. Number of safety valves and sizes in NPS.
f. Safety valve settings in psig.
g. High-limit setting in psig.
h. Operating-control setting.
i. High-fire set point.
j. Low-fire set point.
k. Voltage at each connection.
l. Amperage for each phase.
m. Draft fan voltage at each connection.
n. Draft fan amperage for each phase.
o. Manifold pressure in psig.

Q. Air-to-Air Heat-Recovery Unit Reports:
1. Unit Data:
a. Unit identification.
b. Location.
c. Service.
d. Make and type.
e. Model and serial numbers.

2. Motor Data:
a. Make and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Sheave dimensions, center-to-center, and amount of adjustments in inches.

3. If fans are an integral part of the unit, include the following for each fan:
a. Make and type.
b. Arrangement and size.
c. Sheave make, size in inches, and bore.
d. Sheave dimensions, center-to-center, and amount of adjustments in inches.

4. Test Data (Indicated and Actual Values):
a. Total exhaust airflow rate in cfm.
b. Purge exhaust airflow rate in cfm.
c. Outside airflow rate in cfm.
d. Total exhaust fan static pressure in inches wg.
e. Total outside-air fan static pressure in inches wg.
f. Pressure drop on each side of recovery wheel in inches wg.
g. Exhaust air temperature entering in deg F.
h. Exhaust air temperature leaving in deg F.
i. Outside-air temperature entering in deg F.
j. Outside-air temperature leaving in deg F.
k. Calculate sensible and total heat capacity of each airstream in MBh.

R. Instrument Calibration Reports:
   1. Report Data:
      a. Instrument type and make.
      b. Serial number.
      c. Application.
      d. Dates of use.
      e. Dates of calibration.

3.19 INSPECTIONS

A. Initial Inspection:
   1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
   2. Check the following for each system:
      a. Measure airflow of at least 10 percent of air outlets.
      b. Measure water flow of at least 5 percent of terminals.
      c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
      d. Verify that balancing devices are marked with final balance position.
      e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:
   1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner’s Representative.
   2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of the Board Authorized Representative.
   3. The Owner shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
   4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
   5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
   1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
   2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.20 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Insulation Materials:
a. Calcium silicate.
b. Flexible elastomeric.
c. Mineral fiber.
d. Polyisocyanurate.
2. Fire-rated insulation systems.
3. Insulating cements.
4. Adhesives.
5. Mastics.
6. Lagging adhesives.
7. Sealants.
8. Factory-applied jackets.
9. Field-applied jackets.
10. Identification
11. Tapes.
12. Securements.
13. Corner angles.

1.2 DEFINITIONS

A. Hot Surfaces: Normal operating temperatures of 100 deg F or higher.

B. Dual-Temperature Surfaces: Normal operating temperatures that vary from hot to cold.

C. Cold Surfaces: Normal operating temperatures less than 75 deg F. Note ground loop surfaces vary from 30F to 100F

D. Thermal Resistivity: "R-values" represent the reciprocal of thermal conductivity (K-value). Thermal conductivity is the rate of heat flow through a homogeneous material exactly 1 inch thick. Thermal resistivities are expressed by the temperature difference in degrees F between two exposed faces required to cause one Btu to flow through one square foot of material, in one hour, at a given mean temperature.

E. Density: Is expressed in lb/cu. ft.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thermal resistivity (R-value), thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings:
1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application of Identification
8. Detail application at linkages of control devices.
9. Detail field application for each equipment type.
10. Detail outdoor duct insulation installation.

C. Samples: For each type of insulation jacket, and identification indicated. Identify each Sample, describing product and intended use.
1. Sample Sizes:
a. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
b. Sheet Form Insulation Materials: 12 inches square.

c. Jacket Materials for Pipe: 12 inches long by NPS 2.
d. Sheet Jacket Materials: 12 inches square.
e. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

D. Material Test Reports: From a qualified testing agency acceptable to the authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

E. LEED Submittals:
1. Product Data for Credit EQ 4.1: For adhesives and sealants installed within the building interior, submit one of the following:
a. Documentation indicating compliance with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.
b. Documentation indicating compliance with the VOC limits established in South Coast Air Quality Management District (SCAQMD) Rule #1168.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: Except where indicated otherwise, insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by UL or another testing and inspecting agency acceptable to the authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.
1. Insulation Installed Indoors:
a. Flame-Spread Index: 25 or less.
b. Smoke-Developed Index: 50 or less.
2. Insulation Installed Outdoors:
a. Flame-Spread Index: 75 or less.
b. Smoke-Developed Index: 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project site in original packages and containers with seals unbroken and bearing manufacturer's original labels, including manufacturer's name, product name, and directions for storing, handling, and use.

B. Store materials in a clean, dry, fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.
1. Remove damaged or wet insulation from Project site.

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

1.8 WARRANTY

A. Provide warranty on materials and labor for 18 months starting from date of delivery, or one year from date of Preliminary Acceptance or Substantial Completion, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers and Products: Subject to compliance with requirements, provide one of the following products for each of the products identified:
   1. Flexible Elastomeric Insulation:
      a. Aeroflex USA Inc.; Aerocel.
      b. Armacell LLC; AP Armaflex.
      c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.
   2. Mineral-Fiber Blanket Insulation:
      a. CertainTeed Corp.; Duct Wrap.
      b. Johns Manville; Microlite.
      c. Owens Corning; All-Service Duct Wrap.
   3. Mineral-Fiber Board Insulation:
      a. CertainTeed Corp.; Commercial Board.
      b. Fibrex Insulations Inc.; FBX.
      c. Johns Manville; 800 Series Spin-Glas.
      d. Knauf Insulation; Insulation Board.
      e. Manson Insulation Inc.; AK Board.
      f. Owens Corning; Fiberglas 700 Series.
   4. Calcium Silicate Insulation:
      a. Industrial Insulation Group (The): Thermo-12 Gold.
      b. Johns-Manville.
      c. Owens-Corning Corporation.
      d. PABCO.
      e. Schuller International Inc.
   5. Fire-Rated Blanket Insulation:
      a. CertainTeed Corp.; FlameChek.
      b. Johns Manville; Firetemp Wrap.
      c. Nelson Firestop Products; Nelson FSB Flameshield Blanket.
      d. Thermal Ceramics; FireMaster Duct Wrap.
      e. 3M; Fire Barrier Wrap Products.
      f. Unifrax Corporation; FyreWrap.
      g. Vesuvius; PYROSCAT FP FASTR Duct Wrap.
   6. Mineral-Fiber, Preformed Pipe Insulation:
      a. Fibrex Insulations Inc.; Coreplus 1200.
      b. Johns Manville; Micro-Lok.
      c. Knauf Insulation; 1000 Pipe Insulation.
      d. Owens Corning; Fiberglas Pipe Insulation.
   7. Mineral-Fiber, Pipe and Tank Insulation:
      a. CertainTeed Corp.; CrimpWrap.
      b. Johns Manville; MicroFlex.
      c. Knauf Insulation; Pipe and Tank Insulation.
      d. Manson Insulation Inc.; AK Flex.
      e. Owens Corning; Fiberglas Pipe and Tank Insulation.
   8. Polyisocyanurate Insulation:
      a. Apache Products Company; ISO-25.
      b. Dow Chemical Company (The); Trymer.
      c. Duna USA Inc.; Corafoam.
      d. Elliott Company; Elfoam.
   9. Mineral-Fiber Insulating Cement:
      a. Insulco, Division of MFS, Inc.; Triple I.

b. P. K. Insulation Mfg. Co., Inc.; Super-Stik.

10. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement:
    a. Insulco, Division of MFS, Inc.; SmoothKote.
    b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
    c. Rock Wool Manufacturing Company; Delta One Shot.
11. Polyisocyanurate,Adhesive:
    a. Childers Products, Division of ITW; CP-96.
    b. Foster Products Corporation, H. B. Fuller Company; 81-33.
12. Flexible Elastomeric and Polyolefin Adhesive:
    a. Aeroflex USA Inc.; Aeroseal.
    b. Armacell LCC; 520 Adhesive.
    c. Foster Products Corporation, H. B. Fuller Company; 85-75.
    d. RBX Corporation; Rubatex Contact Adhesive.
13. Mineral-Fiber Adhesive:
    a. Childers Products, Division of ITW; CP-82.
    b. Foster Products Corporation, H. B. Fuller Company; 85-20.
    c. ITW TACC, Division of Illinois Tool Works; S-90/80.
14. ASJ Adhesive, and FSK Adhesive:
    a. Childers Products, Division of ITW; CP-82.
    b. Foster Products Corporation, H. B. Fuller Company; 85-20.
    c. ITW TACC, Division of Illinois Tool Works; S-90/80.
15. PVC Jacket Adhesive:
    a. Dow Chemical Company (The); 739, Dow Silicone.
    b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
    c. Speedline Corporation; Speedline Vinyl Adhesive.
16. Vapor-Barrier Mastic:
    a. Childers Products, Division of ITW; CP-35.
    b. Foster Products Corporation, H. B. Fuller Company; 30-90.
    c. ITW TACC, Division of Illinois Tool Works; CB-50.
    d. Vimasco Corporation; 749.
17. Lagging Adhesives:
    a. Childers Products, Division of ITW; CP-52.
    b. Foster Products Corporation, H. B. Fuller Company; 81-42.
    c. Vimasco Corporation; 136.
18. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products:
    a. Childers Products, Division of ITW; CP-76.
    b. Foster Products Corporation, H. B. Fuller Company; 30-45.
    c. Pittsburgh Corning Corporation; Pittseal 444.
    d. Vimasco Corporation; 750.
19. Metal Jacket Flashing Sealants:
    a. Childers Products, Division of ITW; CP-76-8.
    b. Foster Products Corporation, H. B. Fuller Company; 95-44.
    c. Vimasco Corporation; 750.
20. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:
    a. Childers Products, Division of ITW; CP-76.
21. PVC Jacket:
    a. Johns Manville; Zeston.
    b. P.I.C. Plastics, Inc.; FG Series.
    c. Proto PVC Corporation; LoSmoke.
    d. Speedline Corporation; SmokeSafe.
22. Metal Jacket:
    a. Childers Products, Division of ITW; Metal Jacketing Systems.
    b. IDC Corporation.
    c. RPR Products, Inc.; Insul-Mate.
23. Identification:
    a. Seton.

b. Brady.
c. Best.
d. Milwaukee.

24. ASJ Tape:
    a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
    b. Compac Corp.; 104 and 105.
    c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
    d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
25. FSK Tape:
    a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
    b. Compac Corp.; 110 and 111.
    c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
    d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
26. PVC Tape:
    a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
    b. Compac Corp.; 130.
    c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
    d. Venture Tape; 1506 CW NS.
27. Bands:
    a. Childers Products; Bands.
    b. IDC Corporation.
    c. RPR Products, Inc.; Bands.
28. Insulation Pins and Hangers:
    a. AGM Industries, Inc.; CWP-1.
    b. GEMCO; Cupped Head Weld Pin.
    c. Midwest Fasteners, Inc.; Cupped Head.
    d. Nelson Stud Welding; CHP
29. Wire:
    a. C and F Wire.
    b. Childers Products.
    c. PABCO Metals Corporation.
    d. RPR Products, Inc.

2.2 INSULATION MATERIALS

A. Comply with requirements in PART 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. For equipment applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Calcium Silicate Insulation:
    1. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

2. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
3. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
4. Thermal Conductivity: 0.50 at 200 deg F.
5. Dry Density: 22.0 pcf maximum.
6. Compressive Strength: 60 psi minimum at 5 percent deformation.
7. Fire-Test-Response Characteristics: Provide insulation and related materials with a flame spread index of 0 and smoke developed index of 0, as determined by testing identical products per ASTM E 84 by UL or another testing and inspecting agency acceptable to the authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.

J. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested by UL, or another testing and inspecting agency acceptable to the authorities having jurisdiction, and certified to provide a 2-hour fire rating.

K. Mineral-Fiber, Preformed Pipe Insulation:

L. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg For less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

M. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.
1. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.
2. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches as tested by ASTM E 84.
3. Fabricate shapes according to ASTM C 450 and ASTM C 585.
4. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
   a. Pipe Applications: ASJ.
   b. Equipment Applications: ASJ.

2.3 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by UL or another testing and inspecting agency acceptable to the authorities having jurisdiction.

2.4 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

2.5 ADHESIVES

A. Adhesives, General: All adhesives and mastics installed within the building envelope shall be shown to comply either with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda, or with the VOC limits established in South Coast Air Quality Management District (SCAQMD) Rule #1168.
1. Aerosol adhesives shall comply with Green Seal Standard for Commercial Adhesives GS-36 (2000).

B. Compatibility: Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

C. Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

D. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

F. ASJ Adhesive, and FSK Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

G. PVC Jacket Adhesive: Compatible with PVC jacket.

H. Mastics: Comply with MIL-C-19565C, Type II. Materials shall be compatible with insulation materials, jackets, and substrates.
   1. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
      a. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 permat 43-mildry film thickness.
      b. Service Temperature Range: Minus 20 to plus 180 deg F
      c. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
      d. Color: White.

2.6 Lagging Adhesives: Comply with MIL-A-3316C Class I, Grade A. Materials shall be compatible with insulation materials, jackets, and substrates.
   a. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
   b. Service Temperature Range: Minus 50 to plus 180 deg F.
   c. Color: White.

2.7 SEALANTS

A. Sealants, General: All sealants installed within the building envelope shall be shown to comply either with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda, or with the VOC limits established in South Coast Air Quality Management District (SCAQMD) Rule #1168.

B. Joint Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Permanently flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 100 to plus 300 deg F.
   4. Color: White or gray.

C. Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F
   4. Color: Aluminum.

D. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F.
   4. Color: White.

2.8 JACKETS

A. Factory-Applied Jackets: Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
   1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I..
   2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

B. Field-Applied Jackets: Comply with ASTM C 921, Type I, unless otherwise indicated. Field-applied jackets shall be provided on all piping below 8 ft. height.
   1. PVC Jackets: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
      a. Adhesive: As recommended by jacket material manufacturer.
      b. Color: White.
      c. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

1) Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

d. Factory-fabricated tank heads and tank side panels.

2. Metal Jackets:
   a. Stainless-Steel Jackets: ASTM A 167 or ASTM A 240.
      1) Sheet and roll stock ready for shop or field sizing.
      2) Material, finish, and thickness are indicated in field-applied jacket schedules.
      3) Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper.
      4) Moisture Barrier for Outdoor Applications: 2.5-mil-thick Polysurlyn.
      5) Factory-Fabricated Fitting Covers: Fabricated from the same material, finish, and thickness as jacket. Provide factory-fabricated covers for preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows; tee covers; flange and union covers; end caps; beveled collars; and valve covers. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
   b. Aluminum Jackets: Comply with ASTM B 209, Alloy 3003, Temper H-14.
      1) Sheet and roll stock ready for shop or field sizing.
      2) Finish and thickness are indicated in field-applied jacket schedule.
      3) Moisture Barrier for Indoor Applications: 3-mil thick Polysurlyn.
      4) Moisture Barrier for Outdoor Applications: 3-mil thick Polysurlyn.
      5) Factory-Fabricated Fitting Covers: Fabricated from the same material, finish, and thickness as jacket. Provide factory-fabricated covers for preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows; tee covers; flange and union covers; end caps; beveled collars; and valve covers. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.9 IDENTIFICATION

A. General: Products specified are manufacturer's standard products of categories and types required for each application as referenced in other Division 23 Sections. Where more than single type is specified for listed application, selection is Installer's option but provide single selection for each product category.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Seton.
   2. Brady.
   3. Best.
   4. Milwaukee.

C. Snap-On Plastic Pipe Markers: Manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers.
   1. Lettering: Use piping system terms as indicated and abbreviate only as necessary for each application length.
   2. Arrows: Either integrally with piping system service lettering (to accommodate both directions), or as separate unit, on each pipe marker to indicate direction of flow.

D. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in mechanical identification, with corresponding designations indicated. Use numbers, letters, and terms indicated for proper identification, operation, and maintenance of mechanical systems and equipment.
   1. Multiple Systems: Where multiple systems of same name are indicated, identify individual system number as well as service.

E. Color Coding: Background Lettering
   1. Domestic Cold Water White Black
   2. Domestic Hot Water/ Hot Water Return Blue White
   3. Non Potable Water/ Makeup Water Purple White
   4. Condenser Water Black White
   5. Storm Water Grey White
   6. Air Conditioning Condensate Grey White
   7. Chilled Water Green White

8. Heating Hot Water Orange White
9. Refrigerant Suction/ Hot Gas Clear Black
10. Natural Gas Yellow Black
11. Fire Protection Red White

2.10 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 11.5 mils.
   3. Adhesion: 90 ounces force/inch in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 6.5 mils.
   3. Adhesion: 90 ounces force/inch in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
   1. Width: 2 inches.
   2. Thickness: 6 mils
   3. Adhesion: 64 ounces force/inch in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch in width.

2.11 SECUREMENTS

A. Bands:
   1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.020-inchthick, 3/4-inchwide with wing or closed seal.
   2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:
   1. Capacitor-Discharge-Weld Pins: Copper- coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
   2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following:
      a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
      b. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
      c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
   4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following:
      a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.

b. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   b. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
   c. Adhesive-backed base with a peel-off protective cover.
6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

2.12 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
   1. Verify that systems and equipment to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing, if any. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 INSTALLATION – GENERAL

A. Install insulation materials, accessories, and finishes according to the manufacturer's written instructions with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Keep insulation materials dry during application and finishing.

E. Install insulation with least number of joints practical.

F. Install insulation with longitudinal seams at top and bottom of horizontal runs.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install multiple layers of insulation with longitudinal and end seams staggered.

I. Install vapor barriers on insulated pipes, ductwork, and equipment having surface operating temperatures below 60 deg F.

J. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

K. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

M. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
      a. For below ambient services, apply vapor-barrier mastic over staples.
      b. Exception: Do not staple longitudinal laps on insulation applied to piping systems with a surface temperature at or below 35 deg F.
   4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.
   6. At penetrations in jackets for thermometers, and pressure gages, fill and seal voids with vapor barrier coating.

N. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

O. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

P. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

Q. For above ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.
   4. Manholes.
   5. Handholes.
   6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions in accordance with requirements of approved and tested assembly indicated. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
1. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:
1. Duct: Install insulation continuously through floor penetrations that are not fire rated.
   a. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
   b. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
2. Pipe: Install insulation continuously through floor penetrations.

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
   d. Do not over-compress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
   f. Impale insulation over anchor pins and attach speed washers.
   g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical, where insulation support rings are not provided, or where insulation is to be secured with tie wire or bands, install a girdle network for securing insulation.
    a. Stretch pre-stressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs.
    b. Place one circumferential girdle around equipment approximately 6 inches from each end.
    c. Install wire or cable between two circumferential girdles 12 inches o.c.
    d. Install a wire ring around each end and around outer periphery of center openings, and stretch pre-stressed aircraft cable radially from the wire ring to nearest circumferential girdle.
    e. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:
1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inchcenters, starting at corners. Install 3/8-inch-diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. For Hot Water systems, fabricate boxes from galvanized steel, at least 0.050 inch thick.
3. For Dual Temperature, Chilled Water or Cold Water Systems, or ground loop water systems, fabricate boxes from stainless steel at least 0.050 inch thick.
4. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.6 PIPE INSULATION INSTALLATION – GENERAL

A. General: Requirements in this article apply to all insulation materials, unless more specific requirements are indicated for individual pipe insulation types.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Pipe Elbows: Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Tee Fittings: Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Valves: Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Strainers: Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill

joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

6. Fittings and Unions: Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated on Drawings. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not over compress insulation during installation.
   e. Impale insulation over pins and attach speed washers.
   f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg Fat 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

F. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not over compress insulation during installation.
   e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg Fat 18-footintervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.9 CALCIUM SILICATE INSULATION INSTALLATION

A. Insulation Installation on Boiler Breechings and Ductwork:
1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.

2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch, soft-annealed, stainless-steel wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Apply a thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Straight Pipes and Tubes:
1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Apply a thin finish coat to achieve smooth, uniform finish.

C. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with stainless-steel wire.
3. Finish fittings insulation same as pipe insulation.

E. Insulation Installation on Valves and Pipe Specialties:
1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

F. Metal Jacket: Where indicated, apply metal jacket over finished insulation as specified in this Section for installation of metal jackets.

3.10 POLYISOCYANURATE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 o'clock and 9 o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of polyisocyanurate insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.11 WEATHERPROOF DUCT INSULATION INSTALLATION

A. Provide thickness of polyisocyanurate insulation as indicated in the Schedule at the end of PART 3. Provide on the exterior of all supply, and return, ducts exposed to the weather.

B. Cover insulation with a field-applied jacket.

C. Top of duct insulation shall overlap the side of duct insulation. Side of duct insulation shall overlap the bottom of duct insulation. Provide corner angles at each corner.

D. Top of duct insulation shall be pitched for drainage. Pitch shall be a minimum of 1/2 inch per foot from the high point at the duct horizontal longitudinal centerline to the low points at the outsides of the duct. Insulation thickness at the low points shall be the minimum indicated in the Schedule at the end of PART 3. Duct pitch shall be achieved by either of the following:
1. Tapered insulation.
2. Insulation with tapered fesco board to achieve the pitch.
3. For ducts over 6 ft. wide, tapered continuous wood shims (1 in. wide) running laterally from the duct centerline high point to the low points at the outsides. Shims shall be located at 12 inches o.c. along the length of the duct.

E. Vapor retarder type mastic, or joint sealer, shall be applied on longitudinal and butt joints to prevent moisture and moisture vapor infiltration. Vapor retarder butt joints shall be sealed with 3 in. wide vapor retarder tape.

F. Apply insulation in a solid bed of waterproof adhesive.

G. Tightly wrap the insulation circumferentially with saran film. Overlap the seams by a minimum of 2 inches. Seal the overlapped seams with vapor retarder tape.

H. Secure the insulation with stainless steel bands on 12-inch centers.

I. Jacketing shall be secured with 1/2-inch wide stainless steel bands on 12 inch centers. Rivets, screws, staples, or any other fastener capable of penetrating the underlying vapor retarder shall not be used.

3.12 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

B. Where Stainless Steel, or Aluminum, jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.13 LABELING AND IDENTIFYING INSTALLATION

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.
1. Plastic markers with application systems. Install on pipe insulation segment where required for hot non-insulated pipes.
a. Fasten markers on pipes smaller than 6-inch diameter by one of following methods:
1) Snap-on application of pre-tensioned semi-rigid plastic pipe marker.

2) Adhesive lap joint in pipe marker overlap.
3) Laminated or bonded application of pipe marker to pipe (or insulation).
4) Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4-inch wide, lapped 1-1/2 inches minimum at both ends of pipe marker, and covering full circumference of pipe.

b. Fasten markers on pipes 6-inch and larger diameter by one of following methods:
1) Laminated or bonded application of pipe marker to pipe (or insulation).
2) Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2-inches wide, lapped 3 inches minimum at both ends of pipe marker, and covering full circumference of pipe.
3) Strapped to pipe (or insulation) with manufacturer's standard stainless steel bands.

2. Locate pipe markers and color bands as follows wherever piping is exposed in finished spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
a. Near each valve and control device.
b. Near each branch connection, excluding short take-offs for fixtures and terminal units. Mark each pipe at branch, where flow pattern is not obvious.
c. Near penetrations through walls, floors, ceilings, or enter non-accessible enclosures.
d. At access doors, manholes, and similar access points that permit view of concealed piping.
e. Near major equipment items and other points of origination and termination.
f. Spaced at a maximum of 50-feet o.c. along each run. Reduce intervals to 25 feet in congested areas of piping and equipment.
g. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

3.14 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies in accordance with Division 07 Section "Penetration Firestopping."

3.15 FIELD QUALITY CONTROL

A. Testing Agency: Contractor shall engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:
1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location for each duct system defined in the Article "Duct Insulation Schedule, General".
2. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location for each type of equipment requiring insulation for this project. For large equipment, remove only a portion adequate to determine compliance.
3. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the Article "Piping Insulation Schedule, General".

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements. Architect may reject all work if sample work is found to be defective.

3.16 DUCT INSULATION PERFORMANCE , GENERAL

A. Plenums and Ducts Requiring Insulation:
1. Indoor, supply and outdoor air.
2. Indoor, concealed return located in non-conditioned space.
3. Indoor, return located in non-conditioned space.
4. Indoor, kitchen hood exhaust.

5. Indoor, exhaust between isolation damper and penetration of building exterior.
6. Outdoor, supply, return and outdoor air.

B. Items Not Insulated:
1. Factory-insulated flexible ducts.
2. Factory-insulated plenums and casings.
3. Flexible connectors.
4. Vibration-control devices.
5. Factory-insulated access panels and doors.

3.17 DUCT AND PLENUM INSULATION SCHEDULE

A. INSULATION APPLICATION SCHEDULE
1. General: Abbreviations used in the following schedules include:
a. Field-Applied Jackets: P - PVC, K - Foil and Paper, A - Aluminum, SS - Stainless Steel.

B. Indoor, Concealed duct insulation shall be mineral fiber blanket unless indicated otherwise.

C. DUCT SYSTEMS INSULATION SCHEDULE

DUCT LOCATION	**OUTSIDE AIR, SUPPLY AIR, EXHAUST AIR (DOWNSTREAM OF DAMPER) INSULATION INSTALLED R-VALUE ($H \cdot Ft^2 \cdot deg\ F/BTU$)**	**RETURN AIR INSULATION INSTALLED R-VALUE ($H \cdot Ft^2 \cdot deg\ F/BTU$)**
Exterior of Building (Notes 5, 6, 8)	8.0	8.0
Ventilated Attic (Notes 5, 7)	8.0	8.0
Unvented Attic Above Insulated Ceiling (Notes 5, 7)	8.0	8.0
Unvented Attic with Roof Insulation (Notes 1, 5, 7)	6.0	N/A
Unconditioned Space (Notes 2, 5, 6, 7)	8.0	8.0
Indirectly Conditioned Space (Notes 3, 7)	N/A	N/A
Ceiling Cavity / Shafts / Soffits / Mechanical Spaces and Rooms (Notes 4, 5, 6, 7)	6.0	N/A
Exposed Locations within Conditioned Space	N/A	N/A
Buried	6.0	N/A

NOTE 1: INSULATION R-VALUES, MEASURED IN (H X FT^2 X F)/BTU, ARE FOR THE INSULATION AS INSTALLED AND DO NOT INCLUDE FILM RESISTANCE. WHERE EXTERIOR WALLS ARE USED AS PLENUM WALLS, WALL INSULATION SHALL BE AS REQUIRED BY THE MOST RESTRICTIVE CONDITION OF ASHRAE 90.1-2004 SECTION 5 OR 6.4.4.2. INSULATION RESISTANCE MEASURED ON A HORIZONTAL PLANE IN ACCORDANCE WITH ASTM C518 AT A MEAN TEMPERATURE OF 75F AT THE INSTALLED THICKNESS.

NOTE 2: INCLUDING CRAWL SPACES (BOTH VENTILATED/NON-VENTILATED), FRAMED CAVITIES IN WALLS, FLOOR AND CEILING ASSEMBLIES WHICH (A) SEPARATE CONDITIONED SPACE FROM UNCONDITIONED SPACE OR OUTSIDE AIR, AND (B) ARE UNINSULATED ON THE SIDE FACING AWAY FROM CONDITIONED SPACE.

NOTE 3: RETURN AIR PLENUMS WITH OR WITHOUT EXPOSED ROOFS ABOVE.

NOTE 4: CAVITY CONTAINED WITHIN THE INSULATED BUILDING ENVELOPE.
NOTE 5: VAPOR BARRIER REQUIRED.
NOTE 6: FIELD APPLIED JACKET (STAINLESS STEEL, OR ALUMINUM, FOR EXTERIOR APPLICATIONS, PVC FOR INTERIOR EXPOSED LOCATIONS).
NOTE 7: PROVIDE MINERAL FIBER BOARD WITH FIELD APPLIED JACKET (SS, OR A, EXTERIOR, ALL SERVICE INTERIOR) IN EXPOSED LOCATIONS IN LIEU OF MINERAL FIBER BLANKET.
NOTE 8: PROVIDE POLYISOCYANURATE BOARD INSULATION FOR OUTDOOR DUCTWORK

3.18 EQUIPMENT INSULATION SCHEDULE

A. General: Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment in paragraphs below that are not factory insulated.

C. Heat-exchanger (water-to-water for heating service) insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density. PVC jacket.
2. Mineral-Fiber Pipe and Tank: 2 inches thick. PVC jacket.

D. Ground Loop water pump insulation shall be the following:
1. Mineral-Fiber Board**:** 2 inches thick and 3-lb/cu. ft. nominal density. Vapor barrier.

E. Heating-hot-water pump insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

F. Ground loop-water expansion/compression tank insulation shall be:
1. Flexible Elastomeric: 1 inch thick. Vapor barrier and PVC jacket.
2. Mineral-Fiber Pipe and Tank: 1 inch thick. Vapor barrier and PVC jacket.

G. Heating-hot-water expansion/compression tank insulation shall be one of the following:
1. Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density. PVC jacket.
2. Mineral-Fiber Pipe and Tank: 1 inch thick. PVC jacket.

H. Chilled-water air-separator insulation shall be one of the following:
1. Flexible Elastomeric: 1 inch thick. Vapor barrier and PVC jacket.
2. Mineral-Fiber Pipe and Tank: 1 inch thick. Vapor barrier and PVC jacket.

I. Dual-service heating and cooling air-separator insulation shall be one of the following:
1. Flexible Elastomeric: 1 inch thick. Vapor barrier and PVC jacket.
2. Mineral-Fiber Pipe and Tank: 1 inch thick. Vapor barrier and PVC jacket.

J. Heating-hot-water air-separator insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft**.** nominal density. PVC jacket.
2. Mineral-Fiber Pipe and Tank: 2 inches thick. PVC jacket.

K. Piping system filter-housing (side stream filter) insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density. PVC jacket.
2. Mineral-Fiber Pipe and Tank: 2 inches thick. PVC jacket.

3.19 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.20 PIPING INSULATION SCHEDULE

A. Abbreviations used in the following schedule include:
1. Field-Applied Jackets: P - PVC, K - Foil and Paper, A - Aluminum, SS - Stainless Steel.
2. Pipe Sizes: NPS - Nominal Pipe Size.

B. Minimum HVAC Pipe Insulation Thickness Table:

HVAC INSULATION

HEATING SYSTEMS (Steam and Hot Water) (Note 1)	**FLUID TEMPERATURE RANGE (deg F)**	**INSULATION TYPE / FIELD-APPLIED JACKET / IDENTIFICATION**			**PIPE SIZE AND INSULATION THICKNESS (INCHES)** (Note 5, 6)				
		Glass Fiber	Polyiso-cyanurate	Flexible Elasto-meric	<1" (Note 4)	1" to <1-1/2"	1-1/2" to <4"	4" to 6"	8" and Larger
High Pres-sure/ Tem-perature	306 – 450	X			2-1/2	3	3	4	4-1/2
Medium Pressure/ Temperature	251 – 305	X			2	2-1/2	3	3	3
Low Pres-sure/ Tem-perature	201 – 250	X			1-1/2	1-1/2	2	2	2
Low Tem-perature	106 – 200	X			1	1	1-1/2	1-1/2	1-1/2
Steam Con-densate (for feed water)	Any	X			1	1-1/2	2	2	2
COOLING SYSTEMS									
Ground loop, Chilled Water, Re-frigerant, and Brine	40 – 60	X (Note 2, 7)	X (Note 2, 3, 7)		1/2	3/4	1	1	1
	Below 40	X (Note 2, 7)	X (Note 2, 3, 7)		1	1-1/2	1-1/2	1-1/2	1-1/2
Indoor Air-Conditioning Condensate Drains	40 – 60	X			1	1	1	1	1

NOTE 1: GLASS-FIBER INSULATION ONLY FOR HYDRONIC PIPING.
NOTE 2: (P), (A), OR (SS) FIELD-APPLIED JACKET ON OUTDOOR INSTALLATIONS, EXPOSED AND CONCEALED.
NOTE 3: FOR OUTDOOR USE ONLY.
NOTE 4: PIPING INSULATION IS NOT REQUIRED BETWEEN THE CONTROL VALVE AND COIL ON RUNOUTS, WHEN THE CONTROL VALVE IS WITHIN 4-FEET OF THE COIL AND THE PIPE SIZE IS 1-INCH OR LESS.
NOTE 5: FOR PIPING EXPOSED TO OUTDOOR AIR, INCREASE INSULATION THICKNESS BY 1-INCH.
NOTE 6: INSULATION THICKNESS IS BASED ON INSULATION HAVING A THERMAL CONDUCTIVITY OF 0.22 – 0.25 BTU·INCH/(H·FT^2·deg F)
NOTE 7: VAPOR BARRIER REQUIRED.

3.21 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material for all piping below 8 ft. height. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Provide identification for all piping.

C. Piping, Exposed:
   1. PVC, White – below 8 ft. height: 20 mils thick.

HVAC INSULATION

3.22 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches
   1. Stainless Steel, Type 304, Smooth 2B Finish: 0.020 inch thick.
   2. Aluminum, Alloy 3003, Temper H-14, Smooth Finish: 0.020 inch thick.

C. Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:
   1. Stainless Steel, Type 304, Smooth Finish: 0.020 inch thick.
   2. Aluminum, Alloy 3003, Temper H-14, Smooth Finish: 0.020 inch thick.

D. Piping, Exposed
   1. Stainless Steel, Type 304 Smooth 2B Finish 0.016 inch thick.

3.23 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION

HVAC COMMISSIONING

PART 1 - GENERAL

1.1 OWNER FURNISHED

A. See Section 01 91 13 – General Requirements - Commissioning

1.2 RELATED DOCUMENTS

A. All drawings and general provisions of the contract, including all other Division 01 and general and supplementary conditions.

B. Section 01 91 13 – General Requirements – Commissioning

1.3 SUMMARY

A. The purpose of the commissioning process is to provide the owner/operator of the facility with a high level of assurance that the mechanical systems have been installed in the prescribed manner, and operate within the performance guidelines set in the Contract Documents. The Commissioning Authority shall provide the owner with an unbiased, objective view of the system's installation, operation, and performance. This process is not intended to take away or reduce the responsibility of the design team or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems for beneficial use by the owner. The Commissioning Authority will be a member of the construction team, administrating and coordinating commissioning activities with the design team, construction manager, subcontractors, manufacturers and equipment suppliers.

1.4 REFERENCES

A. See Section 01 91 13 – General Requirements - Commissioning

1.5 SCOPE

A. See Section 01 91 13 – General Requirements - Commissioning

1.6 HVAC SYSTEMS / EQUIPMENT INCLUDED IN THE COMMISSIONING PROCESS:

A. Air Handling Units (DOAS)

B. Energy Recovery Wheels

C. Water Source Heat Pumps

D. Gas-fired Boilers

E. Cabinet Electric Unit Heaters

F. Exhaust Fans

G. Hydronic Pumps

H. Split Ductless Air-conditioners

I. DDC Control Systems

J. Geothermal devices and equipment

K. Variable Speed Drives

PART 2 - COMMISSIONING PLAN

2.1 COMMISSIONING PLAN DOCUMENT

A. See Section 01 91 13 – General Requirements - Commissioning

2.2 COMMISSIONING TEAM

A. See Section 01 91 13 – General Requirements - Commissioning

2.3 CONTRACT DOCUMENT

A. See Section 01 91 13 – General Requirements - Commissioning

2.4 COMMISSIONING MEETINGS

A. See Section 01 91 13 – General Requirements - Commissioning

2.5 MASTER FINDINGS LIST

A. The Commissioning Authority (CxA) or installing contractor will complete Pre-Functional Testing. Commissioning Agent conducts Functional Testing with assistance of installing contractor.

B. All findings from these inspections are documented and are posted to the master findings list and website within two business days.

C. Construction Manager (CM) will regularly distribute findings list to contractors and will hold contractor accountable to: 1.) correct any items and/or 2.) provide electronic responses for each finding.

D. Responsible contractor will correct finding(s) and provide written confirmation that the finding(s) have/has been corrected. If finding was not corrected, contractor provides written explanation.

E. Commissioning findings' status may be considered during the pay application approval process. Approval may be withheld due to unresolved findings and/or findings where written responses have not been provided.

F. CM provides responses back to CxA. All responses are updated to the Master Findings List.

G. Once written responses are provided for each finding, the CxA will re-inspect. The contractor will be back-charged at a rate not to exceed the CxA contract hourly rate for any finding(s) that was/were reported to have been resolved and that are found to be unresolved upon re-inspection.

H. Status will be tracked for each finding and the Master Findings List will be updated accordingly.

I. Once all findings have been resolved and the job is completed, a Final Report will be generated and a final commissioning meeting will be held.

2.6 PRE-FUNCTIONAL TESTING / MANUFACTURER'S CHECKLISTS

A. The Commissioning Authority (CxA) or installing contractor will complete the Pre-Functional Testing forms for each piece of equipment prior to start-up.

B. The equipment manufacturers' checklists must be completed by the installing contractor and reviewed by the Commissioning Authority before start-up can commence.

2.7 START-UP

A. Start-up of major HVAC systems may be witnessed by the Commissioning Authority. The appropriate contractors and/or manufacturer's representative will be required on site to perform start-up. No system will be started until the appropriate Pre-Functional Testing forms have been completed. No system will be started until the Manufacturer's checklists have been completed. Start-up will be performed according to the Manufacturer's recommended procedures. The Commissioning Authority may visit the site to review completeness of installation in conjunction with progress meetings prior to starting HVAC equipment.

B. Construction team members involved in installation, fabrication, manufacture, control, or design of equipment are required to be present at the time of start-up. A factory-authorized technician will be on site to start equipment when required by the specifications. This will minimize delays in bringing equipment on line and expedite acceptable functional performance in accordance with the Owner's Project Requirements (OPR) and the Basis of Design (BOD).

2.8 CONTROLS MONITORING

A. Close monitoring of the Control Contractor's progress will promote efficient coordination of the Test and Balance (TAB) work. The DDC Contractor will be expected to submit point-to-point checklists verifying that his work has been completed and all systems are ready for TAB work and Functional Performance Testing. Programming and graphics will be surveyed by the Commissioning Authority for completeness and conformance with the Owner's Project Requirements (OPR), the Basis of Design (BOD) and the owner's scheduling requirements.

2.9 TAB MONITORING

A. The preliminary TAB report set-up will be reviewed prior to HVAC equipment start-up, in order to assure that the final TAB report format and content is acceptable.

B. TAB work will be monitored so that any problems that prevent or hinder proper air and water balance can be addressed and corrected with minimal delays. By addressing these problems as quickly as possible, we can assure that functional performance testing and owner training will take place on schedule.

C. A pencil copy of the TAB report will be reviewed prior to submission of the final TAB report. A TAB report approved by the Design Engineer of Record will be required before Functional Performance Testing can be

carried out. The Commissioning Authority will visit the site during the TAB process as necessary to verify proper means and methods.

2.10 FUNCTIONAL TESTING

A. The Commissioning Authority will perform or witness installing contractor or manufacturer's representative performing Functional Testing based on the Owner's Project Requirements (OPR) and the Basis of Design (BOD). These tests will be completed for HVAC systems and subsystems.

B. Each major system will be tested. A random sample of each subsystem will be tested. This may be coordinated and witnessed by the Commissioning Authority and the owner's maintenance staff. Witnessing the FPT's will serve as a compliment to the O&M Training. No Functional Testing will be performed until the TAB report and the control contractor Point Installation Verification Checklists have been submitted and reviewed by the Commissioning Authority.

C. Off-season mode testing will be implemented as necessary to assure conformance with the Owner's Project Requirements (OPR) and the Basis of Design (BOD). Installing contractors will be expected to participate as required by the project specifications.

2.11 BUILDING TURN-OVER / OWNER ORIENTATION / USER TRAINING

A. Owner training will be provided by the installing contractor, or manufacturer's representative, and may be witnessed by the Commissioning Authority. This training should include both classroom training and hands-on operational training. The owner may choose to videotape this training for future use. The Commissioning Authority may visit the site during the Turn-Over and Training period to assure that any on-going HVAC related problems are being addressed and corrected in a timely and efficient manner.

B. The Commissioning Authority will assist in the coordination of off-season testing, calibrating, and servicing as specified in the contract documents.

2.12 WARRANTY REVIEW

A. The Commissioning Authority will participate in a 10-month walk-through to observe the operation of the HVAC system. This will include a review meeting with the Facility Maintenance Department, a discussion of warranty issues, energy usage, maintenance practices, usage changes, and chronic problems, as well as other issues affecting the owner and the operation of the HVAC systems.

PART 3 - EXECUTION

3.1 RESPONSIBILITIES OF HVAC EQUIPMENT / SYSTEM INSTALLER

A. The installing contractor in this division shall include in their quote the cost of participating in the commissioning process.

B. Include requirements for submittal data (including partial load data), O&M data, and training in each purchase order or sub-contract.

C. Assure cooperation and participation of specialty sub-contractors such as sheet metal, piping, refrigeration, and water treatment in commissioning activities.

D. Assure participation of major equipment manufacturers in appropriate startup, training, and testing activities.

E. Attend commissioning specific meetings scheduled by the Commissioning Authority or Construction Manager.

F. Assist and participate with the Commissioning Authority in system verification and performance testing, both Pre-Functional and Functional, to achieve design intent.

G. Prepare preliminary schedule for HVAC system inspections, O & M manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, system verification, performance testing, and system completion for use by the Commissioning Authority. Update schedule as appropriate throughout the construction period.

H. Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling startup of HVAC systems.

I. Monitor and respond to the Master Findings List distributed by the Commissioning Authority in writing within five (5) business days in order to expedite corrective actions necessary to achieve design intent. Failure to respond in writing within five business days will result in contractor non-compliance and will warrant the provision of a seventy-two (72) hour notice to comply and/or back charge to the contractor for all necessary

corrective work. Items that are reported to have been corrected but that are found not to have been corrected after a maximum of two re-inspections will result in a back charge to the responsible contractor for any subsequent re-inspection that must be performed by the Commissioning Authority in order to verify that the corrective work has been completed.

J. Notify the Commissioning Authority a minimum of two weeks in advance of scheduled system start-up.

K. Update drawings to as-built condition and review with the Commissioning Authority throughout the construction process.

L. Schedule vendor and subcontractor provided training sessions as required by project specifications.

M. Provide written notification to the CM and Commissioning Authority that the following work has been completed in accordance with the project specifications, and that the equipment, systems and sub-systems are operating in accordance with design intent.
   1. HVAC equipment including heat pumps, boilers, air handling units, fans, ductwork, dampers, piping, pumps, split air-conditioners, fans, etc.
   2. Fire detection and smoke detection devices furnished under other divisions as they affect the operation of the HVAC systems.
   3. That BAS is functioning in accordance with design intent.

N. Participate in the off-season mode testing as required to achieve design intent.

O. Participate in operation and maintenance training as required by project specifications.

P. Provide a complete set of as-built drawings and operation and maintenance manuals for review. The Commissioning Authority shall review the as-built drawings and Operation and Maintenance manuals concurrently with the design team.

Q. In the event that any portion of the work to be completed by the mechanical contractor is subcontracted, ensure compliance with the commissioning process on the part of any individual(s) performing that work. To that end, ensure that each sub-contractor is provided a copy of this specification.

3.2 RESPONSIBILITIES OF TEST AND BALANCE CONTRACTOR (TABC)

A. Include cost for commissioning requirements in the contract price.

B. Attend commissioning specific meetings scheduled by the Commissioning Authority or Construction Manager.

C. Submit the TAB procedures and preliminary TAB report to the Commissioning Authority for review at least two weeks prior to beginning TAB work.

D. Notify the Commissioning Authority a minimum of two weeks in advance of scheduled TAB work.

E. Provide partial, preliminary TAB Reports by phase, by building section, by system, or as required by the Commissioning Authority.

F. Assist the Commissioning Authority in system verification and performance testing, both Pre-Functional and Functional.

G. Monitor and respond to the Master Findings List distributed by the Commissioning Authority in writing within five (5) business days in order to expedite corrective actions necessary to achieve design intent. Failure to respond in writing within five business days will result in contractor non-compliance and will warrant the provision of a seventy-two (72) hour notice to comply and/or back charge to the contractor for all necessary corrective work. Items that are reported to have been corrected but that are found not to have been corrected after a maximum of two re-inspections will result in a back charge to the responsible contractor for any subsequent re-inspection that must be performed by the Commissioning Authority in order to verify that the corrective work has been completed.

H. Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the Commissioning Authority for verification or diagnostic purposes.

I. Participate in the Functional Performance Tests as required to achieve design intent.

J. Provide sound and vibration testing where required to assist in diagnosis of areas exhibiting unacceptable levels of noise or vibration.

K. Participate in the off-season mode testing as required to achieve design intent.

L. Participate in O&M Training as required by project specifications.

M. In the event that any portion of the work to be completed by the test and balance contractor is subcontracted, ensure compliance with the commissioning process on the part of any individual(s) performing that work. To that end, ensure that each sub-contractor is provided a copy of this specification.

3.3 RESPONSIBILITIES OF TEMPERATURE CONTROL CONTRACTOR (TCC)

A. Include cost for commissioning requirements in the contract price.

B. Attend commissioning meetings scheduled by the Commissioning Authority.

C. Assure cooperation and participation of specialty sub-contractors such as TAB and electrical wiring subcontractor in commissioning activities.

D. Review control sequence and component selection for conformance with design intent.
1. Verify that specified safeties and interlocks have been selected.
2. Verify proper selection of control valves and actuators based on design parameters.
3. Verify proper selection of control dampers and actuators based on design parameters.
4. Verify that sensor selection conforms to design intent.

E. Provide the following submittals to the Commissioning Authority:
1. Hardware and software submittals.
2. Control panel construction shop drawings.
3. Narrative description of control sequences for each HVAC system and subsystem.
4. Schematics showing all control points, sensor locations, point names, actuators, controllers and where necessary, points of access.
5. A list of all control points, including analog inputs, analog outputs, digital inputs and digital outputs, and all set points. Include a description of which points will be adjustable from graphic and/or text screen. Include the values of all parameters for each system point. Provide a separate list for each stand-alone control unit.
6. A complete listing of all software routines employed in operating the control system. Also provide a program narrative that describes the logic flow of the software and the functions of each routine and sub-routine. The narrative should also explain individual math or logic operations that are not clear from reading the software listing.
7. Hardware operation and maintenance manuals.
8. Application software and project applications code manuals.
9. Panel and equipment insert documents.

F. Verify that specified interfaces provided by others are compatible with BAS hardware and software.

G. Coordinate installation and programming of BAS with construction and commissioning schedules.

H. Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling startup of HVAC equipment.

I. Provide control system technician to assist during equipment startup.

J. Monitor and respond to the Master Findings List distributed by the Commissioning Authority in writing within five (5) business days in order to expedite corrective actions necessary to achieve design intent. Failure to respond in writing within five business days will result in contractor non-compliance and will warrant the provision of a seventy-two (72) hour notice to comply and/or back charge to the contractor for all necessary corrective work. Items that are reported to have been corrected but that are found not to have been corrected after a maximum of two re-inspections will result in a back charge to the responsible contractor for any subsequent re-inspection that must be performed by the Commissioning Authority in order to verify that the corrective work has been completed.

K. Participate in the Functional Testing as required by the project specifications as required to achieve design intent.

L. Provide a control system technician to assist during Pre-Functional Testing and Functional Testing.

M. Provide system modifications to achieve system operation as defined by the design intent.

N. Provide support and coordination for TAB contractor. Provide all devices, such as portable operator terminals and all software for the TAB to use in completing TAB procedures.

O. Participate in the off-season mode testing as required to achieve design intent.

P. Participate in O&M Training as required by project specifications. Include training on hardware operations and programming.

Q. In the event that any portion of the work to be completed by the temperature control contractor is subcontracted, ensure compliance with the commissioning process on the part of any individual(s) performing that work. To that end, ensure that each sub-contractor is provided a copy of this specification.

END OF SECTION

BUILDING AUTOMATION SYSTEM (BAS)

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the installation of a building automation system (BAS) for control and monitoring of mechanical systems as indicated.

1.2 SYSTEM DESCRIPTION

A. The distributed digital control (DDC) and building automation system (BAS) defined herein shall provide a complete LONMARK® or Native BACnet® Building Automation System (BAS) for all mechanical systems and other facility systems as included in the project documents. The contractor shall provide a complete and operational system to perform all sequences of operations stated in the Article "Sequence of Operation" or as shown on the control drawings.

B. The BAS shall utilize electronic sensing, microprocessor-based digital control, and electronic actuation of dampers and valves to perform the control sequences and functions specified. The BAS for this project shall consist of monitoring and control of the systems indicated.

C. The BAS system shall include a webserver (control system server CSS), a separate operator workstation (OWS), a laptop (portable operator terminal POT), all the software tools required to maintain or configure the server, OWS, and any local devices.

D. All interlock wiring for mechanical system equipment shall be by this contractor unless specifically stated otherwise. This shall include, but not be limited to, items such as thermostats for unit heaters, interlock wiring to central boiler control panels, chiller flow switches, and duct smoke detectors.

1.3 APPLICATION OF OPEN PROTOCOLS

A. Subject to the detailed requirements provided throughout the specification, the BAS and digital control and communications components installed, as work of this contract shall be an integrated distributed processing system utilizing one of the following standards:
   1. BACnet: System components shall communicate using native BACnet in accordance with ASHRAE Standard 135 and current addenda and annexes, including all workstations, all BACnet building controllers (B-BC), advanced application controllers (B-AAC) and all application specific controllers (B-ASC). Gateways to other communication protocols are not acceptable. All controllers must be BACnet Testing Labs listed for their required profile (B-BC, B-AAC or B-ASC).
   2. LonTalk: Provide control products and systems that comply with the latest version of the ANSI/EIA standard 709.1 and the LonTalk protocol of the Interoperability Standards as published by the LONMARK™ Association. All architectures involving tunneling the LonTalk protocol across an IP network must incorporate ISO Layer 3 transparent routing.

B. Throughout these specifications, there are parallel requirements for BACnet or LonWorks systems. Such requirements shall be interpreted in light of whether the contractor is installing a BACnet, LonWorks, or a hybrid system.

1.4 QUALITY ASSURANCE

A. Qualifications: The following companies are acceptable to install a web-based BAS system:
   1. Siemens
      Contact: (630) 852-1700
      Vendor #35461

1.5 CODES AND STANDARDS

A. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standards:
   1. 90.1: Energy Standard for Buildings Except Low-Rise Residential Buildings.
   2. 62.1: Ventilation for Acceptable Indoor Air Quality.

3. 135: BACnet - A Data Communication Protocol for Building Automation and Control Networks, current version including all annexes and addenda.
4. 55: Thermal Environmental Conditions for Human Occupancy.

B. Electronics Industries Alliance:
1. EIA-709.1-A-99: Control Network Protocol Specification.
2. EIA-709.3-99: Free-Topology Twisted-Pair Channel Specification.
3. EIA-232: Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
4. EIA-458: Standard Optical Fiber Material Classes and Preferred Sizes.
5. EIA-485: Standard for Electrical Characteristics of Generator and Receivers for use in Balanced Digital Multipoint Systems.
6. EIA-472: General and Sectional Specifications for Fiber Optic Cable.
7. EIA-475: Generic and Sectional Specifications for Fiber Optic Connectors and all Sectional Specifications.
8. EIA-573: Generic and Sectional Specifications for Field Portable Polishing Device for Preparation Optical Fiber and all Sectional Specifications.
9. EIA-590: Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant and all Sectional Specifications.
10. EIA-852: Tunneling of Component Network Data over IP Channels.

C. Underwriters Laboratories
1. UL 916: Energy Management Systems.

D. NEMA Compliance
1. NEMA 250: Enclosure for Electrical Equipment.
2. NEMA ICS 1: General Standards for Industrial Controls.

E. NFPA Compliance
1. NFPA 90A: "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.
2. NFPA 70: National Electrical Code (NEC).

F. Institute of Electrical and Electronics Engineers (IEEE)
1. IEEE 142: Recommended Practice for Grounding of Industrial and Commercial Power Systems.
2. IEEE 802.3: CSMA/CD (Ethernet – Based) LAN.
3. IEEE 802.4: Token Bus Working Group (ARCNET – Based) LAN.

1.6 DEFINITIONS

A. Acknowledged: Data is broadcast repeatedly until an acknowledgement is received. Used for critical data using one to one bindings only. This type of service shall not be used for one to many bindings.

B. Adjustable (ADJ): A characteristic of a control logic parameter such that it can be varied by the operator without downloading the program.

C. Analog Calibration Offsets: For all analog input measured variables, with the exception of velocity pressure, the value measured by the hardware based analog input point shall be adjusted to match the value reported by a certified test instrument. An analog calibration offset is a parameter that can be added or subtracted from the raw value measured by the sensor to produce a calibrated value used by the control logic and reported to the operator workstations. The initial value of this parameter is set at zero and it is adjusted when the calibration process is executed. This adjustment is referred to as a single point calibration. These parameters are mandatory for all analog inputs except velocity pressure sensors. These offset values are configuration parameters and shall be written to EEPROM. It shall be possible to change the value of these parameters from a graphic page.

D. Advanced Application Controller (AAC): A device with limited resources relative to the Building Controller (BC). It may support a level of programming and may also be intended for

application specific applications. A fully programmable control module. This control module shall be capable of certain advanced features found in Building Controllers (e.g. storing trends, and initiating read and write requests) but it shall not serve as a master controller. Advanced Application Controllers may reside on either the Ethernet/IP backbone or on a subnet. A BACnet device to be used as an AAC will meet the requirements of ASHRAE 135, Annex L and will be listed as an AAC by BACnet Testing Labs. A BTL listed device will carry the BTL Mark.

E. Application Programming Tool: A vendor unique software tool used to create applications for programmable controllers.

F. Application Protocol Data Unit (APDU): A unit of data specified in an application protocol and consisting of application protocol control information and application user data (ISO 9545).

G. Application Specific Controller (ASC): A device with limited resources relative to the Advanced Application Controller (AAC). A pre-programmed control module, intended for use in a specific application. ASCs shall have limited configurability, allowing the user to select various pre-programmed options, but it shall not be fully customizable. A BACnet device used as an ASC will meet the requirements of ASHRAE 135, Annex L and will be listed as an ASC by BACnet Testing Labs. A BTL listed device will carry the BTL Mark.

H. BACnet/BACnet Standard: BACnet communication requirements, as defined by ASHRAE/ANSI 135, current version including all annexes and addenda.

I. Bandwidth Utilization: The average utilization of the network capacity. Network loading is controlled by the use of event driven broadcast based data propagation and the use of appropriate binding services.

J. Binding Services: When the network management tool within Niagara or Plexus is used to establish a binding, one of the following three types of binding services shall be selected:
   1. Unacknowledged: The data being broadcast is sent one time and an acknowledgement of receipt is not required. Used for non-critical data where there is no significant impact should the receiving device have to wait for the next broadcast.
   2. Unacknowledged Repeated: The data being broadcast is sent three times and an acknowledgement of receipt is not required. Used for most process control related data requiring timely receipt of the data.
   3. Acknowledged: The data is broadcast repeatedly until an acknowledgement is received. Used for critical data using one to one bindings only. This type of service shall not be used for one to many bindings.

K. Binding: The concept of associating an output network variable from one device to the input network variable of a second device. There are three types of bindings:
   1. One to One: A single output network variable is bound to a single input network variable
   2. One to Many: A single output network variable is bound to input network variables on multiple devices.
   3. Many to One: Output network variables from multiple devices are bound to a single input network variable on a different device.

L. Broadcasting: The propagation of data from a device to the control network. Software objects that broadcast data to the network shall include the following parameters:

M. Building Automation System (BAS): The entire integrated energy management and control system.

N. Building Controller (BC): A fully programmable control module capable of storing trends and schedules, serving as a router to devices on a subnet, and initiating read and write requests to other controllers. Typically this controller is located on the Ethernet/IP backbone of the BAS. A BACnet device to be used as a BC shall meet the requirements of ASHRAE 135, Annex L and will be listed as a BC by BACnet Testing Labs. A BTL listed device will carry the BTL Mark.

O. Bus Topology: A term used to describe the sequential connection of devices on a LON segment. The communication cable runs from device to device with no tees or stubs from the main communication cable to a device.

P. Change of Value (COV): An event that occurs when a measured or calculated analog value changes by a predefined amount (ASHRAE/ANSI 135-1995).

Q. Channel: A LON network consisting of two segments connected by a physical layer repeater or router configured as a repeater. Each segment can support a theoretical limit of 64 connections.

R. Client: A device that is the requestor of services from a server. A client device makes requests of, and receives responses from, a server device.

S. Configuration Parameter: An input network variable to a controller that is written to the EEPROM.

T. Connection: Made when a device is physically connected to the FTT-10 communication cable. Devices that count against the number of connections limit include LON Talk Adapters (PCLTA, PCC 10 etc.), any sensor, actuator, or controller with a FTT-10 transceiver and Neuron chip, and a router or repeater. Terminators are not considered to be a connection.

U. Continuous Monitoring: Sampling and recording of a variable based on time or change of state (e.g. trending an analog value, monitoring a binary change of state).

V. Control System Server (CSS), Web Server (WS): Provides access to the control system. This device will allow access to the control system with a web browser over the Owner's WAN. As the BAS network devices are stand-alone, the CSS is not required for communications to occur. The webserver will have two NIC cards so that is functions as the bridge between the local supervisory LAN and the Owner's LAN.

W. Controller or Control Unit (CU): Intelligent stand-alone control panel. Controller is a generic reference and is a PCU.

X. The Owner's WAN: Reference to the Owner's Information Technology network, used for normal business-related e-mail and Internet communication.

Y. Direct Digital Control (DDC): Microprocessor-based control including Analog/Digital conversion and program logic

Z. Enumerated SNVT: Defines the format of a single piece of data using a state description concept. The data will consist of a series of integers and each integer shall convey a defined condition or state. The list of available enumerated SNVT types is defined in the LonMark Standard Enumeration Master List, dated May 2002. This document is available on the Echelon.com web site.

AA. Error Rate: A measurement of communication quality that assesses the number of defective data packets as a percentage of the total number of data packets. Defective data packets are generally the result of poor installation practices or improper cable selection.

BB. Event Driven Communication: A term used to describe the propagation of data from a device to the network based on broadcasting rather than polling. The send on delta parameter is used to define the event and the data propagation is further controlled by the minimum and maximum send time parameters.

CC. Free Topology: A data wiring topology that allows for loops, tees, y-connections etc. When this topology is used only one terminator of a specific design is required and allowable cable lengths are significantly reduced.

DD. Functional Profile: A collection of variables required to define a the key parameters for a standard application. As this applies to the HVAC industry, this would include applications like VAV terminal, fan coil units, and the like.

EE. Gateway (GTWY): A device, which contains two or more dissimilar networks/protocols, permitting information exchange between them (ASHRAE/ANSI 135-1995).

FF. Hand Held Device (HHD): Manufacturer's microprocessor based device for direct connection to a Controller.

GG. Host-Based Controller: Applicable only to Lon-based controllers where the on-board Neuron chip is used solely as the Communications Interface and a processor independent from the Neuron chip to is used to execute Application control and I/O processes.

HH. JACE: Java Control Engine. Term used within the Niagara Framework to describe a component that serves several key functions:
1. Serve as the LANID.
2. Collection of data from a FTT-10 LonTalk channel.
3. Transmission of data to operator workstations on the TCP/IP network.
4. Location for time schedules to support all of the devices on the LonTalk channel.
5. Support for 1 LonTalk channel (two segments, 40 nodes each).
6. Location for trend logs for all data to be trended from the devices on the LonTalk channel.
7. Location for alarm handling software. The JACE shall process event broadcasted data from the devices (alarm indication) and enter the appropriate alarm information in the alarm reporting system at the TCP/IP level.

II. Local Supervisory LAN Interface Device (LANID): Device used to facilitate communication and sharing of data throughout the BAS and the Owner's WAN

JJ. LonMark Profile: To enhance interchangeability of control components at the sensor, actuator, terminal unit controller and package equipment controller level, the LonMark Association has created profiles that define the network image for these devices. These profiles define mandatory input and output variables and configuration parameters and a required format for each. Conformance to a LonMark profile provides to the facility owner the opportunity to replace a control component manufactured by one vendor with a similar component manufactured by a different vendor provided the embedded application of the replacement controller meets the sequence of control requirements.

KK. Media Access Control address (MAC): Hardware address that uniquely identifies each node of a network. Each different type of network medium requires a different MAC layer.

LL. Managed Communication: Transmission of data from a controller to a data manager, which in turn re-broadcasts the data to a second controller.

MM. Manual Control: Where the operator takes control of an end device and forces a specific position or state. The manual mode and the desired manual position or states are parameters that are set by the operator.

NN. Many to One: Output network variables from multiple devices are bound to a single input network variable on a different device.

OO. Maximum Send Time Parameter: Parameter used to ensure the periodic update of network data. If a time period equal to the value of this parameter has expired without a broadcast of the variable, a re-broadcast of the current value shall be executed. See also "Send on Delta" and "Maximum Send Time."

PP. Maximum Send Time: Adjustable parameter that defines the maximum time period between broadcasts of a software object's data to the network. Should the value of a software object remain constant over an extended period of time, the value will be rebroadcast once every maximum time period.

QQ. Minimum Send Time Parameter: Parameter used to control unnecessary broadcasting of data onto the network. Broadcast of an updated value shall not occur unless a time period equal to the value of this parameter has expired. The expiration of the time period does not mandate a re-broadcast. See also "Send on Delta" and "Maximum Send Time" definitions.

RR. Minimum Send Time: Adjustable parameter that defines a mandatory time period during which no broadcasting of data will occur. Once this time period has been exceeded without a broadcast, the send on delta parameter or the maximum send time parameter shall determine when a broadcast is initiated.

SS. Multiple Controller Integrated Control (MCIC): Where multiple controllers with I/O are used to control a single mechanical system, which is sub-divided into a collection of processes to be controlled. All primary measured variables and the end device associated with a single process along with the primary control logic for the process shall be contained within a single controller. Secondary data from one process that affects the control of another process may be sent from one controller to the primary controller controlling the process. When data is sent from one controller to another controller, broadcasting concepts as defined above must be used. If the data being received over the network only affects the general thermodynamic or psychometric performance of the process but does not have a significant affect on safety or equipment protection then unacknowledged repeated binding services shall be used. If the data being received over the network has a safety or equipment protection impact, then acknowledged repeated binding services shall be used. In both cases peer-to-peer communication is mandatory. All controllers must be on the same channel. Managed communication shall not be used to move data between the multiple controllers.

TT. One to Many: A single output network variable is bound to input network variables on multiple devices.

UU. One to One: A single output network variable is bound to a single input network variable.

VV. Open Database Connectivity (ODBC): Open standard application-programming interface (API) for accessing a database, making access to any data, regardless of which database management system (DBMS) is handling the data, possible.

WW. Operator Interface (OI): A device used by the operator to manage the BAS.

XX. Operator Workstation (OWS): Used to interface with the BAS system via the internet or the Local Supervisory LAN.

YY. Peer-to-Peer Communication: Data is broadcast from its origin and is received by the final device requiring the data without being received and retransmitted by a third device.

ZZ. Polling Communication: The concept of a control device requesting a network variable from a second control device at a specified interval. Polling communication is typically used to populate dynamic data on an active graphic page and for temporary or short term trending of data where the trend data is not stored at the controller level.

AAA. Portable Operators Terminal (POT): Laptop PC used both for direct connection to a controller and for remote dial up connection.

BBB. Primary Control Unit (PCU): A fully programmable device capable of carrying out a number of tasks including control and monitoring via direct digital control (DDC) of specific systems.

CCC. Protocol Implementation Conformance Statement (PICS): A written document, created by the manufacturer of a device, identifying the particular options specified by BACnet that are implemented in the device.

DDD. Repeater: A physical device used to connect two segments and isolate physical problems. Typically required to allow the use of additional devices or additional cable length.

EEE. Router: A device that connects two or more networks at the network layer.

FFF. Segment: A single section of a LON network that contains no routers or repeaters.

GGG. Send on Delta Parameter: A parameter used to control unnecessary broadcasting of data onto the network. For binary data the send on delta parameter is assumed to be a change of state.

HHH. Send on Delta: Adjustable parameter that defines a requirement to broadcast when the data generated by the software object changes by an amount that exceeds this parameter's value. For binary data this parameters defaults to a change of state. The broadcast of data is initiated when this criteria and the minimum send time requirement have been met.

III. Simple SNVT: Defines the format of a single piece of data. The definition of a simple SNVT in the master list of SNVTs will include the type of variable being measured (temperature, electric current, power etc.), the data type (signed integer, unsigned integer, floating point etc.), the data range, the resolution of the data and the engineering units.

JJJ. Smart Device: A control I/O device such as a smart sensor (SS) or smart actuator (SA) that can directly communicate with the controller network to which it is connected rather than through a binary or analog signal.

KKK. Standard Network Variable Type (SNVT): Data format statement for implicit (open) communication on a LonTalk network. The current master list of SNVTs is available from Echelon.com in a document defined as SNVT Master List, Version 11, Revision 2, dated May 2002.

LLL. Standardized Query Language (SQL): Standardized means for requesting information from a database.

MMM. Stand-Alone Controller: A stand-alone controller has provisions for all of the physical inputs and physical outputs associated with a single mechanical component such as a terminal unit, air handling unit, chiller or boiler. The controller shall also have embedded in it all of the control logic that associated the physical inputs to the physical outputs. A stand-alone controller may rely on other networked devices for time schedule inputs and trend data storage.

NNN. Structured SNVT: Defines the format of a network variable that contains several different data elements. A simple SNVT or an enumerated SNVT may define each data element within a structured SNVT.

OOO. Supervisory Logic: The concept of gathering performance data from multiple terminal units to determine if a specific condition exists within the family of terminal devices.

PPP. Terminator: An electronic component that consists of a resistive and capacitive circuit specifically designed to enhance the quality of communications on a segment. On a bus topology, a terminator is connected to each end of a segment. For a channel consisting of two bus topology segments, a total of 4 terminators are required, one at each end of each segment.

QQQ. Test Mode: A concept where the operator from the operator workstation can interrupt the flow of data from a sensor to the control logic and insert a mandatory test value or test state to be used by the control logic. The test mode and the desired test value or states are parameters that are set by the operator.

RRR. Unacknowledged Repeated: The data being broadcast is sent three times and an acknowledgement of receipt is not required. This type of service shall be used for most process control related data requiring timely receipt of the data.

SSS. Unacknowledged: The data being broadcast is sent one time and an acknowledgement of receipt is not required. This type of service shall be used for non-critical data where there is no significant impact should the receiving device have to wait for the next broadcast.

TTT. Web Server: Refer to "Control System Server."

UUU. XIF File: A file indicating the interface specifications for LonMark devices.

VVV. XML (Extensible Markup Language): A specification developed by the World Wide Web Consortium.

BUILDING AUTOMATION SYSTEM (BAS)

1.7 FUNCTIONAL INTENT

A. Where detailed functional or performance requirements are specified, products intended for the Project, conforming to the specified requirements, must be submitted to, and approved by, the Owner prior to shipment to the Project site.

1.8 SUBMITTALS

A. Electronic Submittals: While all requirements for hard copy submittal apply, control submittals and O&M information shall also be provided in electronic format as follows.
   1. Drawings and Diagrams: Shop drawings shall be provided on electronic media as an AutoCAD 2000 or later version drawing file and/or Adobe Portable Document Format file. All 'x reference' and font files must be provided with AutoCAD files.
   2. Other Submittals: All other submittals shall be provided in Adobe Portable Document Format (PDF). Provide documents, such as Cheat Sheets and Trouble Shooting Guide, in rich text format (rtf) or Microsoft Word format as required.

B. Product Data: For each control device, panel, and accessory indicated or furnished. Include dimensions, capacities, performance and electrical characteristics, and material finishes. Include installation and start-up instructions. When manufacturer's cutsheets apply to a product series rather than a specific product, clearly indicate applicable data by highlighting or by other meansGeneral catalogs shall not be accepted as cutsheets to fulfill submittal requirements.

C. Shop Drawings: Submit shop drawings for each control system, including a complete drawing for each air handling unit, system, pump, device, etc. with all point descriptors, addresses and point names indicated. Each shop drawing shall contain the following information:
   1. System Architecture and System Layout:
      a. One-line diagram indicating schematic locations of all control units, workstations, LAN interface devices, gateways, etc. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, baud rate, and type of each LAN. For LonTalk systems indicate all LonTalk nodes, including Neuron ID and domain, sub-network and channel addresses. Indicate media, protocol, baud rate, and type of each LAN. All optical isolators, repeaters, end-of-line resistors, junctions, terminators, ground locations etc. shall be located on the diagram.
      b. Provide floor plans locating all control units, workstations, servers, LAN interface devices, gateways, etc. Include all WAN and LAN communication wiring routing, power wiring, power originating sources, and low voltage power wiring. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, baud rate, and type of each LAN. For LonTalk systems provide as-built network architecture drawings showing all LonTalk nodes, including Neuron ID and domain, sub-network and channel addresses. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the floor plans. Wiring routing as-built conditions shall be maintained accurately throughout the construction period and the drawing shall be updated to accurately reflect accurate, actual installed conditions.
   2. Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. Include contractor written description of sequence of operation.
   3. All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.
   4. Completed/final points list and sequence of operation shall be submitted no later than the 50% completion point of system installation.
   5. With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance

number). See Division 23 Section " Building Automation System (BAS) - Software and Programming," PART 3 for additional requirements.

6. Label each control device with setting.
7. Label each input and output with the appropriate range.
8. Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc. as applicable. Also identify the specification section and specification reference.
9. Provide a valve or damper and the associated actuator information including size, Cv, design flow, design pressure drop, manufacturer, model number, close off rating, etc. Indicate normal (fail) positions of spring return valves and dampers. This is the valve or damper position with no power to the actuator.
10. Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, boiler burner, chiller, RTU, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination drawings on separate drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring, which are existing, factory-installed and portions to be field-installed. For all devices with safety circuits, incuding burners and chillers, field wiring will be labeled and all added devices will be properly mounted. Any internal wiring changes shall be approved by the manuafacturer in writing. If for example a gas booster needs to be tied into the burner circuit the manaufacturer shall identify the terminal points and provide an updated control diagram.
11. Sample Operator Interface Graphic Screens for each unique type of system, with final screens to be received 60 days prior to system startup.
12. Details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations.
13. Sheets shall be consecutively numbered.
14. Each sheet shall have a title indicating the type of information included and the HVAC system controlled.
15. Table of Contents listing sheet titles and sheet numbers.
16. Legend and list of abbreviations.
17. Provide an operating schedule for review. The schedule will have a schedule for each AHU/RTU and the associated equipment. Terminal units serving the dean’s office and associated administrative areas will have a separate schedule from the classrooms.

D. Product Line Demonstrated History: The product line being proposed for the project must have an installed history of demonstrated satisfactory operation for a length of 1 year since date of final completion in at least 10 installations of comparative size and complexity. Submittals shall document this requirement with references.

E. Qualifications: For manufacturer, companies, Contractor and key personnel.

F. Checkout and Testing Forms: Submit a blank copy of the forms that will be used during Point-to-Point Checkout, Prefunctional Checkout, and Functional Performance Testing as outlined in Division 23 Section " Building Automation System (BAS) - Commissioning." Those forms should be structured to capture the following information at a minimum during each particular testing phase.

1. Point-to-Point Checkout Form containing the following information:
   a. Each point is addressed, labeled and that proper communication exists between the controller and the field device.
   b. Documents that installed condition match the control drawings and that any changes or differences are noted on the drawings.
2. Prefunctional Checkout Forms containing the following information:
   a. Documents correct voltage and or current present as well as verifying circuits are free from grounds or faults for each control device.

b. Obtain and Record Test and Balance settings and incorporate into the BAS. Information from the TAB contractor shall include:
   1) Water and air system differential pressure and flow settings.
   2) AHU minimum outside air control point or damper setting.
c. Calibration data for all sensing and actuating devices recording final measured and displayed value. Record the type and model of the meter(s) that determined the measured value for analog inputs.
d. For analog outputs record both the displayed output as well state of the receiving device.
e. For digital input/outputs record the signal at the controller and the state of the sensing/control device.
f. For actuators:
   1) Check to ensure that actuated device moves smoothly and results are repeatable thru full range and seals tightly when the appropriate signal is applied to the operator.
   2) Check for appropriate fail position, and that the stroke and range is as required.
   3) For sequenced electronic actuators, calibrate in accordance with manufacturer's instructions to required ranges. Record final settings.
g. For all valves and actuators, verify the actual position against the Operator Interface readout. Set pumps to normal operating mode. With command valve closed, verify that valve is closed, and adjust output zero signal as required. With command valve open, verify position is full open and adjust output signal as required. Command the valve to not less than three (3) intermediate positions. If actual valve position doesn't correspond correctly, replace actuator.
h. Valve leak check: Verify proper close-off of the valves. Ensure the valve seats properly by simulating the maximum anticipated pressure difference across the circuit.
i. For air and water flow measuring stations the data recorded will include the independent flow measurement, area, and the independently measured output of the flow station. The BAS input from the flow station and any factors used to calculate the flow including area and any constants used in the calculation of flow. Two sets of data shall be collected. The first at design flow and the second at 50% of design flow. It is not acceptable to simply add a correction factor to address differences between the flow station and the independent reading.
j. For Operator Interfaces and Web accessible display:
   1) Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
   2) Output all specified BAS reports for review and approval.
   3) Verify that the alarm pop ups, printing, and logging are functional and in accordance with requirements.
   4) Verify that all points are trended and are archiving to disk. Provide a sample to the Commissioning Authority and the Owner for review.
   5) Verify that paging/dial-out alarm annunciation is functional.
   6) Verify the functionality of remote Operator Interfaces and that a robust connection can be established consistently.
   7) Verify that required third party software applications required with the bid are installed and are functional.
k. For all actuating devices record final settings for device.
l. Document verification of point to graphics binding for all points displayed on the workstation and that webserver display have been mapped correctly, and display the correct information.
m. Document that the webserver is on the Owner's LAN and can be viewed from off site (another authorized location), that the modem is connected, and that the BAS is accessible via modem by the contractor.

3. Functional Performance Forms shall contain:
   a. List of all sequences, modes of operation and setpoint that initiates each sequence and/or mode. For each confirm that proper sequence of operation. Document any variance between designed sequence and actual condition.
   b. Record tuning parameters and response time for each control loop.
   c. Document all alarm and safeties test and final results.
   d. Results of trends including controlled points, setpoints, actual readings and other point defined by the Owner Authorized Representative.

G. Testing Plan:
1. Submit a plan for executing all phases of testing and completion of checkout forms. This includes the following: manufacturers' normal testing, point-to-point testing, pre-functional testing, and functional performance testing. The testing plan shall show the overall milestones of the controls work and testing of the controls system.
2. Provide the schedule for completing each phase of testing for each system or set of equipment including, but not limited to, air handlers, chillers, boilers, unit-vents, VAV boxes, network wiring, and operator workstations. Schedules shall show the time frame needed to complete the tasks.
3. The testing plan shall identify other trade milestones that impact the successful completion of during each phase of testing.
4. This plan is not meant to take precedence over any other plan but is intended to provide coordination assistance to all trades as the project is scheduled.

H. Open Protocol Information:
1. General: Provide all information necessary for review of the proposed system, including information required by the authority maintaining the protocol standard to determine if the product selected for implementation complies with the protocol standards specified.
2. LonWorks Systems:
   a. Binding table indicating all Network Variables used in the project, Neuron ID and domain, subnet and channel address, and associated bound variables. Clearly indicate which parameters of a functional profile are bound and can be overridden.
   b. A point binding diagram shall be provided with each control schematic depicting all bound network variables along with the associated functional profiles.
   c. LonMark functional profile certifications.
   d. For Host-Based Controllers: Controller programming and configuration tool and or plug in required for all controllers with a minimum of 3 licenses as applicable.
   e. For non-host Controllers: LonTalk Neuron C source code and/or Neuron C application programming interface tool (3 licenses) and associated files required for all controllers.
   f. Backup of systems configuration database on CD. This shall be provided at Preliminary Acceptance and at the end of the warranty period.
   g. Documentation of all explicit messaging.
   h. XIF files for all LonMark components.
3. BACnet Systems:
   a. BACnet object description, object ID, and device ID, for each I/O point.
   b. Documentation for any non-standard BACnet objects, properties, or enumerations used detailing their structure, data types, and any associated lists of enumerated values.
   c. Submit PICS indicating the standardized BACnet device profile, functionality and configuration of each controller along with proof of BTL listing.

I. Framed Control Drawings: After completion of installation and check out, but prior to training, laminated control drawings including system control schematics, sequences of operation, and panel termination drawings, shall be provided in panels for major pieces of equipment. Terminal unit drawings shall be located in the central plant equipment panel or mechanical room panel.

J. Control Logic Documentation (to be received and updated by 50% completion):
   1. Submit control logic program listings (for graphical programming) and logic flow charts illustrating (for line type programs) to document the control software of all control units.
   2. Control logic shall be annotated to describe how it accomplishes the sequence of operation. Annotations shall be sufficient to allow an operator to relate each program component (block or line) to corresponding portions of the specified Sequence of Operation.
   3. Include written description of each control sequence.
   4. Include control response, settings, setpoints, throttling ranges, gains, reset schedules, adjustable parameters, and limits.
   5. Sheets shall be consecutively numbered.
   6. Each sheet shall have a title indicating the controller designations and the HVAC system controlled.
   7. Include Table of Contents listing sheet titles and sheet numbers
   8. Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation. This set will count toward the required number of Operation and Maintenance materials specified below.

K. Training Plan:
   1. Training shall be provided in eight, four-hour sessions. A training plan is not required for opposite season or refresher training.
   2. The material to be covered shall be further sub-divided into descriptions of the material to be covered in every 15 minutes. See Division 23 Section " Building Automation System (BAS) – Commissioning," for specific items to be addressed.
   3. The descriptions shall include not only the material to be covered but also its location in the Operation and Maintenance Manual or the Training Manual including Section and page number.

L. Operation and Maintenance Manual: (All documentation to be received and updated prior to training)

M. In addition to other copies required, submit one copy of the materials directly to the Owner's operation staff.
   1. Submit maintenance instructions and spare parts lists for each type of control device, control unit, and accessory.
   2. Submit BAS User's Guides (Operating Manuals) for each controller type and for all workstation hardware and software and workstation peripherals.
   3. Submit BAS advanced Programming Manuals for each controller type and for all workstation software.
   4. Include all as built submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions, and spare parts lists) in maintenance manual, in accordance with requirements of Division 01 Section "Operations and Maintenance Manual."

N. Training Manual: Submit training manual electronically for review. Once accepted, provide three hard copies and one electronic copy of the training manual at the start of training. Note only the initial 8 hours of training which include the Cheat Sheets will occur before the demonstration is completed. Include the following:
   1. Cheat Sheets or quick reference section with step-by-step guidance with a level of detail that will allow someone with no experience with the control system to follow the instructions. The quick reference guidance can be provided one of two ways: screen prints with bubbled text describing the navigation required or written description of the steps to be taken with screen prints provided to facilitate the written explanation. The required cheat sheets shall include:
      a. Logins and logoffs.
      b. Adjust and restore setpoints.

c. Overrides and releasing overrides. Include instructions for running a report to list all points currently overriden.
d. Start, group, plot and export Trends.
e. Adjust schedules and add holidays.
f. Processing of alarms including acknowledgement, review of alarm report, and clearing of alarm history.
g. Backup and restoration of system data.
h. Demonstrate how to clear/reset all field devices that may require manual intervention.
i. Demonstrate how to reset motor starter and the significance of Hand-Off-Auto switch position on motor starters.
j. Demonstration of each input and output device. Provide a picture of each input or output device with a brief narrative on its operation.
k. Demonstrate how to place the boiler or chiller system into manual control and boiler control, and how to restore the system to BAS control.

2. Operating instructions including system startup and shutdown, seasonal and emergency instruction.
3. Trouble Shooting Guide. Include actions to be taken to trouble shoot problems with the OWS, PCU's CSS, and local control devices.
4. Setpoint Table.
5. Preventative maintenance instructions.
6. Color print of each unique screen.
7. Final Sequence of Operations. This document shall be printed but shall also be provided electronically in rich text format (rtf). The sequence shall provide not only the original design sequence from the specifications and drawings but also the any changes to the sequence.
8. Complete set of the design control drawings (provided by the Architect on 11"x17" sheets). The manual will have a TAB for these drawings. The printed drawings will come from the Architect or Engineer.
9. List of all alarm points and alarm priority.

O. Video Training: The following training shall be recorded on a CD using screen capture software. Any files required to run the CD will be provided along with a file with the instruction on how to view the CD. The cadence of the video training shall be such that an inexperienced person can listen to the narrative and execute those steps on controls system while watching the CD. Include a screen view recording the actual video feed to the monitor for the work station penetration while narrating the associated steps.
1. Quick reference procedures. The taping of these procedures must include both a screen view preferably recording the actual video feed to the monitor while narrating the associated steps.
a. Login and logoff to control system as well as Microsoft XP login;
b. Adjust and restore setpoints.
c. Overrides and releasing overrides, as well as running a report to list all points currently overriden.
d. Start, group, plot and export Trends.
e. Adjust schedules and add holidays.
f. Processing of alarms including acknowledgement, review of alarm report and clearing of alarm history.
g. Backup and restoration of system data.
h. Demonstrate workstation menu penetration and broad overview of the various workstation features.
i. Demonstrate all operations and functions that can be performed at the supervisory or local controllers as well as system display artifacts such as the indication that a point has failed or lost communication.

P. Demonstration of portable operator interface device display capabilities.

Q. Manufacturers Certificates: For all listed and/or labeled products, provide certificate of conformance. Include all LonMark functional profiles certifications for systems used on this project.

R. Product Warranty Certificates: Submit manufacturers product warranty certificates covering the hardware provided.

1.9 PROJECT RECORD DOCUMENTS

A. The Project Record documents that have not already been submitted as part of the Operating and Maintenance Manual or Training Manual are to be submitted with the Record Documents. Any documents in the Operating and Maintenance Manual or Training Manual that have changed since they were submitted will need to be re-submitted as part of the Project record documents. All of these documents maybe submitted electronically. Update all documents, sequences and graphics to include final naming which matches owners facility standards and installed equipment tags.

B. Record copies of product data and control shop drawings updated to reflect the final installed condition.

C. Record copies of approved control logic programming and database on CDs. The CDs will contain all information required to reinstall the control system program. It will include actual setpoints and settings of controls, final sequence of operation, including changes to programs made after submission and approval of shop drawings and including changes to programs made during specified testing. One set of CD's will be stored at the property in the main control panel and the second set will be provided to the Owner's Operations.

D. Graphic Software: Record copies of approved project specific graphic software on CDs.

E. For LonTalk systems provide as-built network architecture drawings showing all LonTalk nodes, including Neuron ID and domain, sub-network and channel addresses. For BACnet systems provide as-built network architecture drawings showing all BACnet nodes including a description field with specific controller identification, description and location information.

F. Include individual floor plans with controller locations with all interconnecting wiring routing including space sensors, LAN wiring, power wiring, low voltage power wiring. Indicate device instance, MAC address and drawing reference number.

G. Provide record riser diagram showing the location of all controllers.

H. Maintain project record documents throughout the warranty period and submit final documents at the end of the warranty period

1.10 OPERATOR INTERFACE

A. The Operator Interface (OI) shall provide for overall system supervision, graphical user interface, management report generation, alarm annunciation, remote monitoring, and trend reporting. . Refer to Division 23 Section " Building Automation System (BAS) - Operator Interfaces."

1.11 SYSTEM ARCHITECTURE

A. Application of Open Protocols:
   1. Subject to the detailed requirements provided throughout the specifications, the BAS and digital control and communications components installed, as work of this contract shall be an integrated distributed processing system utilizing the following standards:
      a. LonTalk: Provide control products and systems that comply with the latest version of the ANSI/EIA standard 709.1 and the LonTalk protocol of the Interoperability Standards as published by the LONMARK™ Association. All architectures involving tunneling the LonTalk protocol across an IP network must incorporate ISO Layer 3 transparent routing.
      b. BACnet or Hybrid System: The system architecture shall consist of a BACnet IP Router, a single Local Area Network (LAN) or two-level LANs that support BCs, AACs,

ASCs, Operator Workstations (OWS), Smart Devices (SD), and Remote Communication Devices (RCDs) as applicable. In no event shall there be more than two levels of LAN topology within the system, excluding wiring to sensors with no control intelligence.

B. The system provided shall incorporate hardware resources sufficient to meet the functional requirements specified. The Contractor shall include all items not specifically itemized in these Specifications that are necessary to implement, maintain, and operate the system in compliance with the functional intent of these Specifications.

C. The system shall be configured as a distributed processing network(s) capable of expansion as specified below. Refer to the network architecture on the BAS drawings for other requirements and details.

D. The system architecture shall consist of an Ethernet-based, wide area network (WAN), a single Local Area Network (LAN) or multi-leveled LANs that support PCUs, Operator Workstations (OWS), and Remote Communication Devices (RCDs) as applicable. The following indicates a functional description of the BAS structure.
   1. The Owner's WAN: Intranet-based network connecting multiple facilities with a central data warehouse and server, accessible via standard web-browser. This is an existing infrastructure and contractor is not required to configure any components of this WAN.
   2. Local BAS Supervisory LAN: The Local BAS Supervisory LAN shall be an Ethernet-based, 100 Mbps LAN connecting Primary Control LANs and OWSs. The LAN serves as the inter-PCU gateway and OWS-to-PCU gateway and communications path and as the connection point for the Owner's WAN. LAN shall be IEEE 802.3 Ethernet over Fiber or Category 5 cable with switches and routers that support 100 Mbps throughput. Power-line carrier communication shall not be acceptable for communications. The higher level layers of this network shall be the following:
      a. LonWorks Supervisory LAN: Individual Primary Control LonTalk Networks routed over IP using LonTalk to IP routers.
      b. BACnet Local Supervisory LAN: BACnet/IP as defined in Addendum A (Annex J) of the BACnet standard, and shall share a common network number for the Ethernet backbone, as defined in BACnet.
   3. Primary Controller LAN ('Primary LAN'): High-speed, peer-to-peer communicating LAN used to connect and Primary Control (PCUs) and communicate exclusively control information. Acceptable technologies include:
      a. LonTalk: The LonTalk standalone BAS shall be comprised of a network of PCUs supporting LonTalk protocol (EIA 709.1) and twisted pair, bus topology transceivers (EIA 709.3). The network shall communicate at 78 kbps. The network shall be installed utilizing the Bus Topology. The network shall consist of a single channel with 2 segments. Each segment shall be limited to a maximum of 40 nodes or as required to meet performance and standalone requirements, and to meet the requirements for response time, trending and bandwidth utilization as specified elsewhere in the specifications. A terminator shall be installed at both ends of each segment.
      b. BACnet: Network used to connect AACs, ASCs or SDs. These can be Master Slave/ Token Passing or polling, or ARCnet in accordance with IEEE 802.4, in addition to those allowed for Primary Controller LANs. Network speed vs. the number of controllers on the LAN shall be dictated by the response time and trending requirements. The primary network shall communicate at a minimum of 38 kbps. Each secondary network may support up to 32 communicating devices without segmentation or repeaters subject to the requirements for response time, trending and bandwidth utilization.

E. Dynamic Data Access: Any data throughout any level of the network shall be available to and accessible by all other devices, Controllers and OWS, whether directly connected or connected remotely.

F. Remote Data Access: The system shall support the following methods of remote access to the building data.
   1. Dial-in via minimum of a 56k modem. The purpose of the remote access via phone is to allow for the contractor to access the control system. Dial-in connection shall allow access to all control system facilities and graphics with appropriate password the Owner shall provide and pay for the voice grade phone line to support this remote connection.
      a. Browser-based access: A remote user, connecting via the Owner's WAN and using a standard browser shall be able access all control system facilities and graphics with proper password. The remote access user will not need to load Java or other applications to view the web pages.

G. Network Performance: The communication speed between the controllers, control LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. Contractor shall submit guaranteed response times with shop drawings including calculations to support the guarantee. In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein. Contractor shall reconfigure LAN as necessary to accomplish these performance requirements. The performance will also include the trending of all AI, AO and DI points at 15-minute intervals. Generally requirements do not apply when a remote connection must be established via modem:
   1. 5 seconds between a Level 1 (critical) alarm occurrence and annunciation at operator workstation.
   2. 10 seconds between a Level 2 alarm occurrence and annunciation at operator workstation.
   3. 20 seconds between and a Level 3-5 alarm occurrence and annunciation at operator workstation.
   4. 10 seconds between an operator command via the operator interface to change a setpoint and the subsequent change in the controller.
   5. 5 seconds between an operator command via the operator interface to start/stop a device and the subsequent command to be received at the controller.
   6. 10 seconds between a change of value or state of an input and it being updated on the operator interface.
   7. Graphic Display, 10 seconds between an operator selection of a graphic and it completely painting the screen and updating all points.
   8. Graphic Refresh, every 15 seconds the graphic shall automatically refresh all graphic data.

H. Control Systems Server (CSS) and Operator Work Station (OWS): These are two separate computers that maintain the systems configuration and programming database and is the operating platform for the operator interface (OI). It shall hold the backup files of the information downloaded into the individual controllers and as such support uploading and downloading that information directly to/from the controllers. It shall be located within each facility. It shall also act as a control information server to non-control system based programs. It shall allow secure multiple-access to the control information. Refer to Division 23 Section " Building Automation System (BAS) - Operator Interfaces," for requirements.

I. The PCUs shall monitor, control, and provide the field interface for all points specified. Each PCU shall be capable of performing all specified energy management functions, and all DDC functions, independent of other PCUs and operator interface devices as more fully specified in Division 23 Section " Building Automation System (BAS) - Field Panels."

J. Systems Configuration Database: The system architecture shall support maintaining the systems configuration database on a server or workstation on the Local Supervisory LAN. User tools provided to the Owner shall allow configuring, updating, and maintaining current configurations and settings whether they are initiated at the server or the end device.
   1. Database Schema shall be published and provided to the Owner to facilitate easy access to the data.
   2. Database shall be ODBC compliant or a data access driver shall be provided to act as an ODBC or OLE DB data provider.

3. For a LON system: The SCD and associated network services shall be Echelon LonWorks Network Services (LNS) (latest version) compliant, no exceptions allowed. The Network Management Application shall be LonMaker™ for Windows (latest released version) service tool (including hardware, software and any peripheral devices required) and is to be used for commissioning and management of the LonTalk control architecture, no exceptions allowed. The network management service tool shall remain on the project as the property of the Owner. A copy of the LonTalk network database shall be archived on the service tool and the operator interface, documenting system bindings and node addressing. In addition all system variables shall have a plain English language description for each variable. This service tool shall be used for all system maintenance and expansion, so that the network database backup remains current

K. Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other nodes on the network. If a LAN is severed, two separate networks shall be formed and communications within each network shall continue uninterrupted.

L. All line drivers, repeaters, terminators, signal boosters, and signal conditioners shall be provided as necessary for proper data communication.

M. Anytime any controller's database or program is changed in the field, the controller shall be capable of automatically uploading the new data to the OWS and CSS.

1.12 WARRANTY MAINTENANCE

A. Contractor shall warrant all products and labor for a period of one (1) year after Final Acceptance.

B. The Owner reserves the right to make changes to the BAS during the warranty period. Such changes do not constitute a waiver of warranty. The Contractor shall warrant parts and installation work regardless of any such changes made by the Owner, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS.

C. At no cost to the Owner, during the warranty period, the Contractor shall provide maintenance services for software and hardware components as specified below:
1. Maintenance services shall be provided for all devices and hardware specified in Division 23 Section " Building Automation System (BAS)" Sections. Service all equipment per the manufacturer's recommendations. All devices shall be calibrated within the last month of the warranty period.
2. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by the Owner to the Contractor.
   a. Response by telephone to any request for service shall be provided within two (2) hours of the initial telephone request for service.
   b. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the site within eight (8) hours of the initial telephone request for such services, as specified.
   c. Emergency service shall be available on a 24-hour, 7-day-a-week basis.
3. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by the Owner to the Contractor.
   a. Response by telephone to any request for service shall be provided within eight (8) working hours (contractor specified 40 hr/week normal working period) of the initial telephone request for service.
   b. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained

in the system to be serviced, shall be dispatched to the site within three (3) working days of the initial telephone request for such services, as specified.

4. Telephonic Request for Service: Contractor shall provide up to three telephone numbers for the Owner to call in the event of a need for service. At least one of the lines shall be attended 24 hours a day, 7 days a week. Alternatively, pagers can be used for technicians trained in system to be serviced. A technician shall respond to every call within 15 minutes.
5. Technical Support: Contractor shall provide technical support by telephone throughout the warranty period.
6. Preventive maintenance shall be provided throughout the warranty period in accordance with the hardware component manufacturer's requirements.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from weather.

1.14 LISTING AND LABELING

A. The BAS and components shall be listed by Underwriters Laboratories (UL 916) as an Energy Management System.

B. BACnet controllers, B-BC, B-AAC, B-ASC, etc. shall carry the BTL Mark for their device profile.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials shall be new, the best of their respective kinds without imperfections or blemishes, and not be damaged in any way. Used equipment shall not used in any way for the permanent installation except where drawings or specs specifically allow existing materials to remain in place.

2.2 UNIFORMITY

A. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF CONTROL SYSTEMS

A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.

3.3 DIGITAL CONTROL STATIONS, CONTROLLER QUANTITY AND LOCATION

A. Individual Digital Control Stations (DCS) are referenced to indicate allocation of points to each DCS and DCS location. Digital control stations shall consist of one or multiple controllers to meet requirements specified.

B. Where a DCS is referenced, Contractor shall provide at least one (1) controller, and additional controllers as required and in sufficient quantity to meet the requirements of this Specification. Restrictions in applying controllers are specified in Division 23 Section " Building Automation System (BAS) - Field Panels." This Contractor shall extend power to the DCS from an acceptable power panel. If the contractor wishes to further distribute panels to other locations, contractor is responsible for extending power to that location also. Furthermore, contractor is

responsible for ensuring adequate locations for the panels that do not interfere with other requirements of the project and maintain adequate clearance for maintenance access.

C. Contractor shall locate DCSs as required. It is the Contractor's responsibility to provide enough controllers to ensure a completely functioning system, according to the point list, trending requirements and sequence of operations.

D. Contractor shall provide the following, as a minimum:
   1. One DCS (including at least one controller) in each heating water and chilled water plant mechanical room.
   2. One DCS (including at least one controller) for each air handler located in an applicable mechanical room.
   3. One controller shall be provided for each terminal unit unless indicated otherwise.

3.4 SURGE PROTECTION

A. The Contractor shall furnish and install any power supply surge protection, filters, and other equipment as necessary for proper operation and protection of all PCUs, operator interfaces, printers, routers, gateways and other hardware and interface devices. All equipment shall be capable of handling voltage variations 10% above or below measured nominal value, with no affect on hardware, software, communications, and data storage.

3.5 CONTROL POWER SOURCE AND SUPPLY

A. Extend all power source wiring required for operation of all equipment and devices provided under Division 23 Building Automation System (BAS) Sections and Sequences of Operation.
   1. Control panels shall not share a power circuit. Power supplied to the panels shall have dedicated circuits and the circuit location shall be documented in the panel.

3.6 STARTUP, COMMISSIONING, AND TRAINING

A. Refer to Division 23 Section "Building Automation System (BAS) - Commissioning."

B. Provide a minimum of 40 hours of combined classroom and onsite training.

3.7 SEQUENCE OF OPERATION

A. Refer to Division 23 Section "Building Automation System (BAS) - Sequences of Operation."

3.8 IDENTIFICATION STANDARDS

A. Controller Identification. All controllers shall be identified by a plastic engraved nameplate securely fastened to the outside of the controller enclosure.

B. Panel Identification. All local control panels shall be identified by a plastic engraved nameplate securely fastened to the outside of the controller enclosure.

C. Field Devices. All field devices shall be identified by a typed (not handwritten) securely attached tag label.

D. Panel Devices. All panel devices shall be identified by a typed label securely fastened to the backplane of the local control panel.

E. Raceway Identification. All the covers to junction and pull boxes of the control system raceways shall be painted blue or have identification labels stating "Control System Wiring" affixed to the covers. Labels shall be typed, not hand written.

F. Wire Identification. All low and line voltage control wiring shall be identified by a number, as referenced to the associated control diagram, at each end of the conductor or cable. Identification number shall be permanently secured to the conductor or cable and shall be typed

3.9 EXHIBITS

A. Exhibits A through E are attached.

END OF SECTION

BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS

EXHIBIT A Sample Cheat Sheet

EXHIBIT B Sample Operating Instructions, Startup/Shutdown, Seasonal and Emergency

EXHIBIT C Sample Setpoint Table

EXHIBIT D Sample Preventative Maintenance Instructions

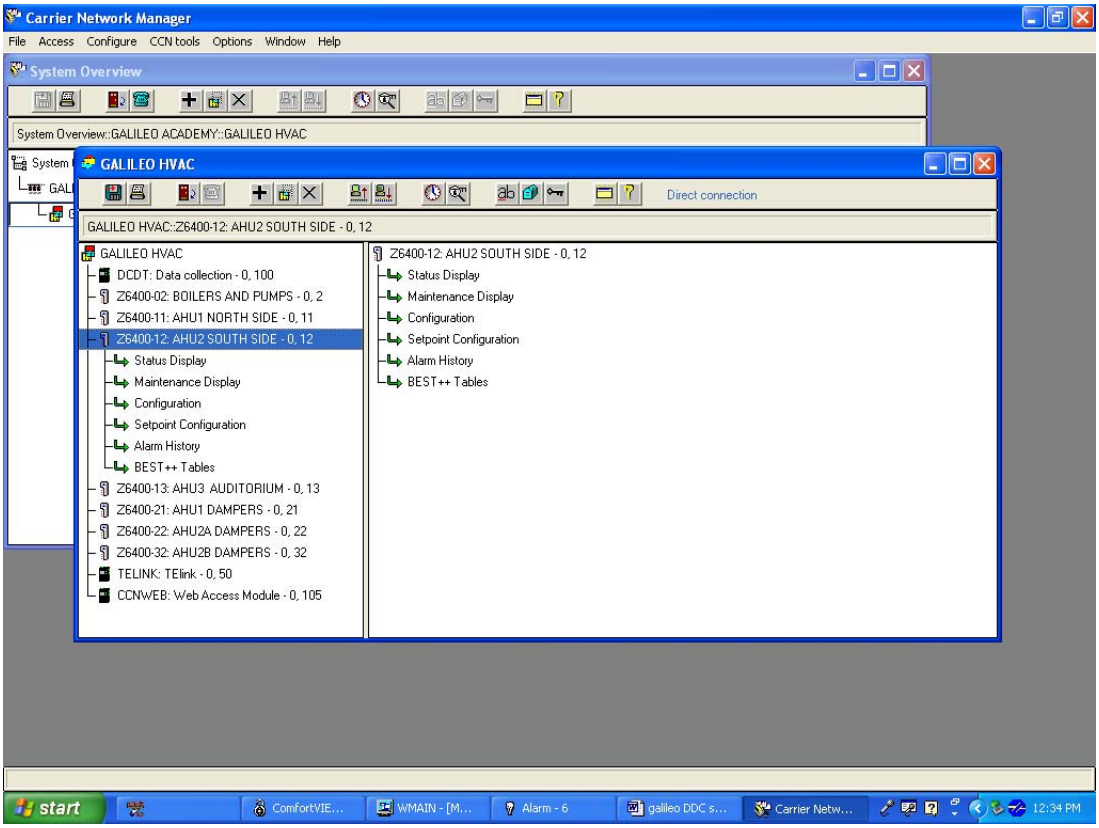
EXHIBIT E Sample Trouble Shooting Instructions

EXHIBIT F Sample Control Hardware Operation Instructions

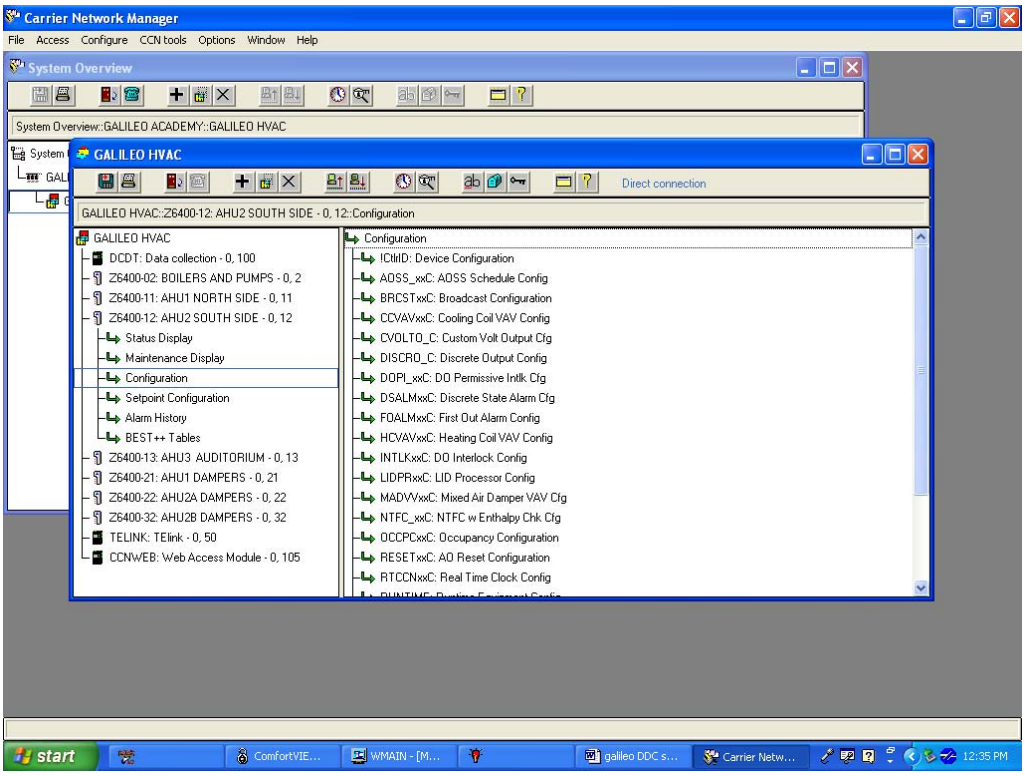
BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS

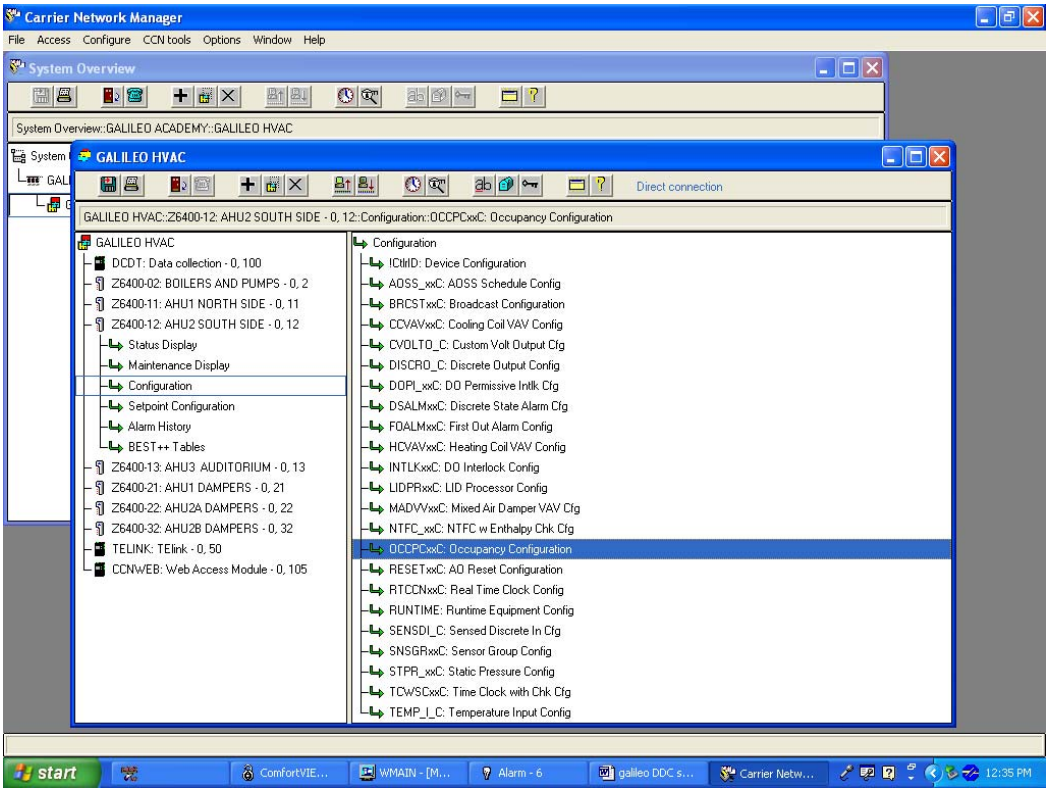
EXHIBIT A – Sample Cheat Sheet

SCHEDULING/OCCUPANCY: From Windows Desktop:
double click on Network Manager
double click on Galileo Academy
double click on Galileo HVAC
Follow the same navigation directions as shown in the Set point adjust , then
select controller that operates device or equipment that will be adjusted for
Example for AHU 2
double click Z6400-12 AHU2 SOUTH SIDE
click on Configuration
On right side of screen
double click OCCPCxxC which is the number of the schedule you wish to modify
At the occupancy

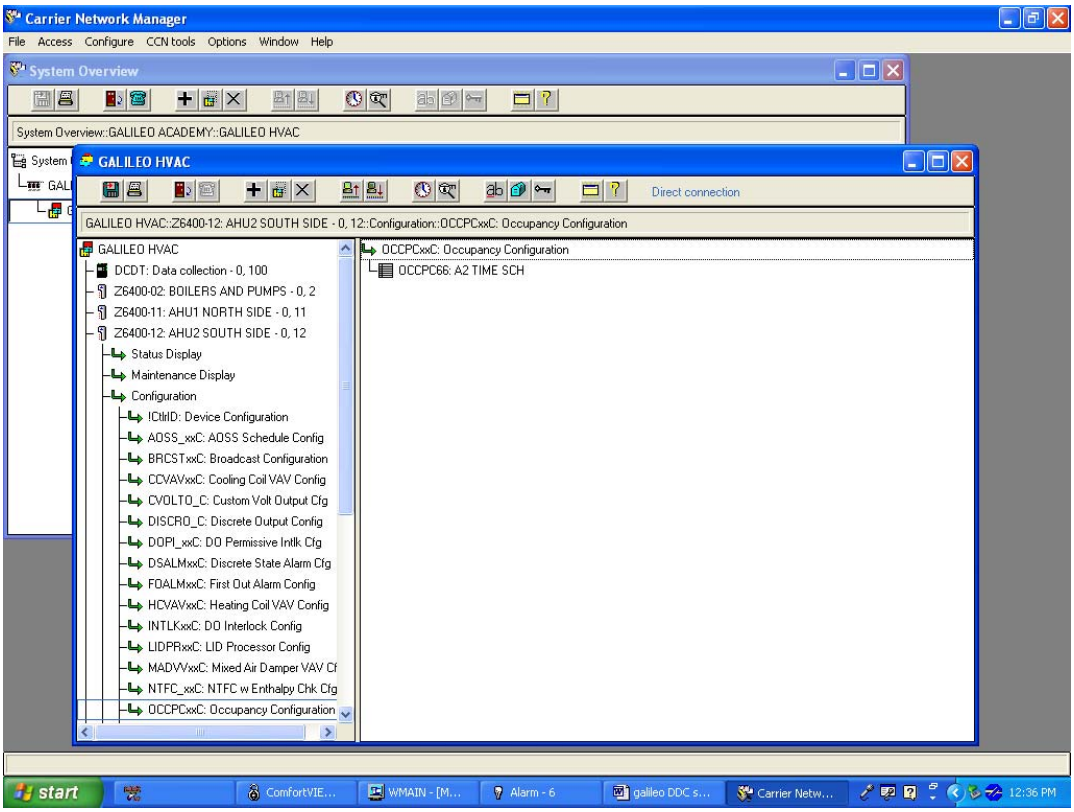


BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS



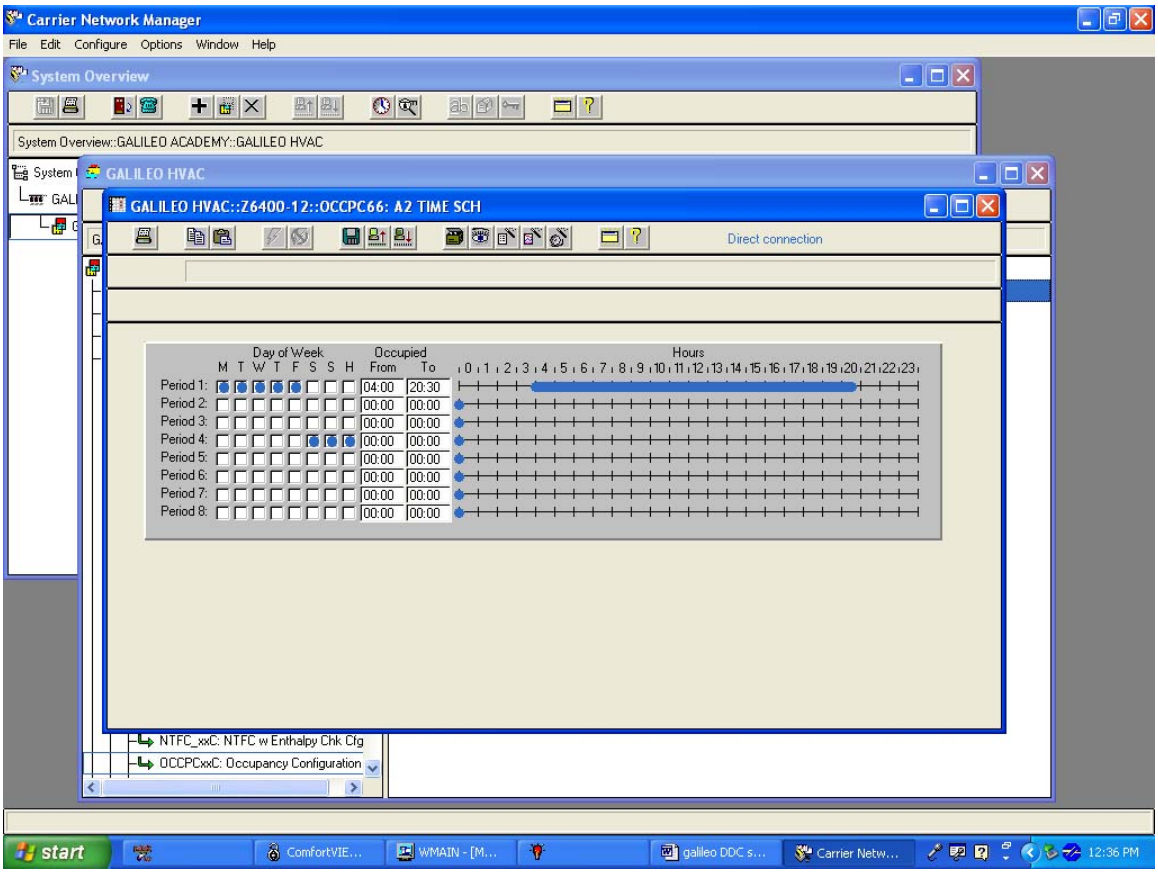


BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS



BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS

Period 1 is normal weekday schedule ensure that each weekday has a blue dot. The blue dot must be present for each day the schedule is to be active.
To modify start time click on the From box and input the new start time
To modify stop time click on the To box and input the new stop time
At tool bar, click on floppy disk icon to save the schedule
At tool bar click on the computer symbol with the down arrow. This will update the local controller.
To exit click lower X to close screen.



BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS

EXHIBIT B
Sample Operating Instructions, Startup/Shutdown, Seasonal and Emergency

[Insert the Owner's name here]
Startup/Shutdown and Seasonal Instructions

Startup: Defined as any time that the automation system has been disabled, whether due to power outage, manual disabling, or control program reboot.

- Prior to enabling the control system, place all equipment in the OFF or LOCAL mode of operation.
- The power to each of the control panels should be OFF at the circuit breaker.
- Verify that the latest version of each control program is available at the operator workstation.
- Starting with the control panel for the central plant (boilers then chillers), turn the circuit breaker that serves the control panel ON. Verify that the controller has power, is functioning properly, and is communicating. If this is verified, examine the outputs to see which are being enabled. Starting with pumps, then fans, then major mechanical pieces (boilers, chillers, etc.), enable each piece of equipment in the manual mode. Once everything has returned to automatic operation, verify the operation and stability of control loops.
- If the controller has no power once the circuit is turned ON, verify the fuses in the control panel. If they are failed, replace them; if they are fine, then confirm power at the power terminals of the controller. If there is no power, correct the wiring within the panel or call a service technician to do so. If the wiring is in tact, replace the controller or call a service technician to do so.
- If the controller has power, but no program loaded, or if a controller has been replaced, download the latest version of the program into the controller. Follow the rest of the startup procedure.
- Repeat the previous 3 steps for each control panel in the system.
- Once all systems are restored, verify that trend logs have been reestablished. If they have not, restore the trends as noted in the operations binder. After two hours, review the system status and trend reports. If fine, repeat every ½ day for the next 3 days to maintain system operation.
- If, after 2 hours, the system is unstable, note the issues with the trend logs. If temperature and pressure values are cycling, then adjust the control loop parameters to improve performance and review every hour until stable. If, instead, the system appears unresponsive, verify the status of the dial-in support system, and call a service technician to diagnose the issue.

Shutdown: Required for service work to system components, when emergencies require the system to be disabled, when work being performed in the building requires a power shutdown, or when the building power fails.

- Prior to shutting down each panel, make sure that there is a backup of each controller's program. If a backup of a program does not exist, and power is still available to the panel, upload the program and store for future download.
- Go to each control panel and pull the fuses that interrupt the 120 V power to the panel.
- Turn the circuit breaker feeding the panel to the OFF position.
- Place mechanical equipment in the OFF position for power outages, either voluntary or unexpected. Place mechanical equipment in the HAND/LOCAL mode if equipment needs to operate during a control system shutdown.

Seasonal adjustments:

- Changeover from summer to winter operation (or vice versa) is automatic in the building automation system.
- After performing all preventative maintenance on equipment to be operated for the seasonal changeover, place that system in the REMOTE/AUTO mode (ie. As summer approaches, make sure that chillers are in the position to be enabled).
- Establish trend logs for temperatures and pressures associated with the systems to be started. Once enabled, view trend logs on a daily basis to verify stable operation.
- Follow manufacturer's recommendations for seasonal tuning of control loops, clearing of trend logs and alarms (to free up storage and computing space). Make sure that before purging any information, that the information has been uploaded to the workstation and stored on a disk for later retrieval.
- Once the new season has been firmly established, place the equipment that is no longer needed into the LOCAL/OFF mode for preventative maintenance.

BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS

[Insert the Owner's name here]
Emergency Operation Instructions

FAILURE OF BUILDING AUTOMATION SYSTEM

- Boilers should fail to control by their local aquastat (in winter mode) and pumps should fail on.
- Variable flow pumps will run at 60% of their maximum speed.
- Air handling units will have to be enabled manually
- Heating valves will fail open and chilled water valves closed. Actuators will have to be manually positioned until control power is restored.
- All other system heating valves will fail to supplying heat
- Once power and control are restored, equipment can be set to the automatic position

Failure of one boiler on a design day (outside air less than 0°F)

- Monitor the discharge air temperature of the air handling systems. If they are still making setpoint, then monitor the preheat coil discharge temperature. If the preheat coil discharge temperature is sufficient to keep the coils from freezing, then the system has satisfactory capacity.
- If either the discharge air temperature or preheat coil discharge temperature are at a point where they cannot satisfy the load or protect the coils, then reduce the outside airflow rate to ½ of the system capacity. This condition will provide inadequate ventilation to the building, and should be used only when a boiler has failed and there is not enough system capacity to provide adequate heat. Once the boiler operation has been restored, or the outside air temperature rises above 0°F, the outside air should be restored to its minimum value.

Failure of temperature sensor (either cut or shorted leads)

- An alarm condition at the BAS will notify the operator that the temperature value is out of range (too high or too low depending on the type of failure)
- Replace the sensor with the appropriate type, if available.
- If the appropriate type is not available, but another type is available, attempt to install the type available on a temporary basis. If successful, allow the system to operate automatically, but replace the sensor with the appropriate type within 48 hours.
- If there is no replacement available, view the trend history to determine the position of the valves and dampers on the system at the time of the failure. Manually override the software to place the valves and dampers in those positions. Monitor the operation of the system on a regular basis (every ½ hour for normal spaces, every ¼ hour for more critical spaces) and adjust the valve and damper positions accordingly. Replace the sensor with any type of useable sensor as soon as possible; replace with the appropriate type of sensor within 48 hours.

BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS

EXHIBIT C
Sample Setpoint Table

System	Description	Tag	Default	High Alarm	Low Alarm	What happens when changed
Boiler	Primary Hot Water Supply	PHWSTSP	180	205	165	The primary is designed for 180 degrees with reset on the secondary. Lowering the primary will prohibit heating during the coldest days and raising it will possibly trip the operating high limit or high limit safety on the boiler.
Chiller	Primary Chilled Water Supply	PCHWSTSP	45	55	42	The primary is designed for 45 and there is variable flow on the secondary. Raising the setpoint will reduce dehumidification and prohibit cooling during the warmest days, and lowering the limit will result in wasted energy and could cause the chiller to cycle on safeties.
Various	Space Temperature Setpoint	SPCSP	70W/ 74S	80	67	The system is designed to provide 70 in winter and 74 in summer. Changing significantly above or below these setpoints might provide little additional heating or cooling.
AHU	Discharge Air Temperature Setpoint	DATSP	Reset	75	52	The discharge air temperature setpoint is reset by the variance of space from its setpoint. This value will vary, and should not be overridden by the operator unless there is a problem with the space temperature sensor.

BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS

EXHIBIT D
Sample Preventative Maintenance Instructions

Software preventative maintenance (performed once every 3 months):

- Review the software to look for things that may be in override or not performing properly.
- Review trend logs to look for control loops that need tuning.
- Review list of items that have been written in the issues log
- Add or modify graphics to meet their need.
- Back-up all files and do any maintenance on disks.

Hardware preventative maintenance (performed once every 6 months):

- Check calibration on sensors and transducers
  - Space temperature (¼ each session)
  - Duct temperature (all)
  - Water temperature (all, includes removing sensor and verifying the integrity of the conductive compound)
  - Humidity (all – replace sensor every 2 years)
  - Carbon Dioxide (all – replace sensor every 2 years)
  - Carbon Monoxide (all – replace sensor per manufacturer's recommendation)
  - Refrigerant (all – replace sensor per manufacturer's recommendation)
  - Freeze protection (all – verify correct positioning and security of contacts)

- Check out all damper and valve actuators for proper performance
  - For each, apply full control signal, apply zero control signal, remove power, manually operate, and restart
  - Inspect linkages and clamps for proper operation
  -
- Check batteries where applicable (UPS, etc.)

- Address any hardware items on the engineers issue log

BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS

EXHIBIT E
Sample Trouble Shooting Instructions

Basic Troubleshooting and Operations

- If the Front End PC is up and running but not displaying data for the HVAC Graphic Screens (showing "DOWN"): shutdown the PC using the standard Windows shutdown sequence and reboot it. If the data is still showing "DOWN" in the data fields, go to the UNC controller(s) (just outside the boiler room at north wall of boiler room) and check for power. Remove the black plastic cover using both hands (one hand on each side): once the cover is removed, check for power indicator lights. The heartbeat light should be flashing red. The Lon "RXD" and "TXD" lights should be flashing. If these lights are not on, chances are the 24VAC power to the unit is off. Check the transformer next to the control panel for power. It too has an indicator light. Try resetting the circuit breaker built into the transformer. If power to the UNC is on, you have the option of resetting the UNC. This should only be done in critical situations or when the building is generally unoccupied (certain equipment may shutdown during this procedure). To shutdown and reboot the UNC, pull out the hardwired plug connector at the top of the UNC. This kills power to the UNC and removes the battery backup also. Wait 5 seconds. Reconnect the connector. Check for status indicator lights. The heartbeat light should come immediately. The LON "TXD" and "RXD" lights should come on within 60 seconds. The Ethernet "DATA" light should come on within 30 seconds.

- If a piece of electrical equipment is commanded on and not running, it is probably locked out by a safety device or an electrical problem. Check for alarms at the Front End PC. If an alarm exists, correct the problem and reset the alarm device. If no alarms are present, check for electrical problems. Warning, this should only be done by a trained qualified person. If the piece of equipment has a motor starter, check for power. If there is a motor starter with a Hand-Off-Auto switch, make sure the switch is in "Auto" or "Hand" (usually "Auto") Verify that the thermal overloads have not tripped. Verify that the fuses have not blown. Verify that all appropriate disconnects and service switches are in the correct position. Review the Precision Control shop drawings to see what connection if any the control system has to the piece of equipment.

- Low Temperature Switch Activation: these switches are typically installed on fan systems with hydronic coils. They have long (usually 20 feet) sensing tubes connected to the main electric switch chassis, which also has a setpoint adjustment and reset button. Once the temperature along any point of the sensing tube drops below the setpoint, the device trips. Manual reset is required by pressing a button on the cover. The reset button will only work if the temperature at the sensing tube rises above the setpoint. See the device data sheet for more information.

- Duct Smoke Detector Activation: If a duct smoke detector activates, wait for the environmental conditions to clear before attempting to reset the device. The device can be reset using the reset button on the front cover, or by removing and restoring power to the unit. See the device data sheet for more information.

- DDC Control Panels: make sure power to the control panel and all the DDC controllers contained inside is turned on. Transformer boxes next to the control panels have status indicator lights on them. Make sure the light is on. Make sure the power switch is on. If the circuit breaker is tripped, reset it. All DDC controllers in the panel will have blinking lights on them. All will have both red lights for power status, and yellow/green lights for communications status.

- Before manually overriding a motorized actuator, disconnect power.

- Always use caution when overriding outside air dampers, control valves, motors, etc, especially during the winter months. Leaving devices and/or equipment in an overridden state can lead to equipment malfunction and/or damage.

BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS

- Keep all HVAC control panels locked to prevent unauthorized tampering and damage from surrounding environments.

- Keep software backups for the HVAC control system in a known, accessible secured area. Anticipate the backup disc set will be needed at a future date.

- The Front End PC Server must remain on at all times. Various services and tasks run continuously and the system must stay up and running and connected to the network. Log off the Front End Graphics system when done using it. Do not shut the computer off. Logging off will prevent unauthorized use. It is recommended that no other customer installed application software be installed on the Front End PC Server. This will only result in reduced efficiency and slower operation and can ultimately lead to communications failure and system disruption.

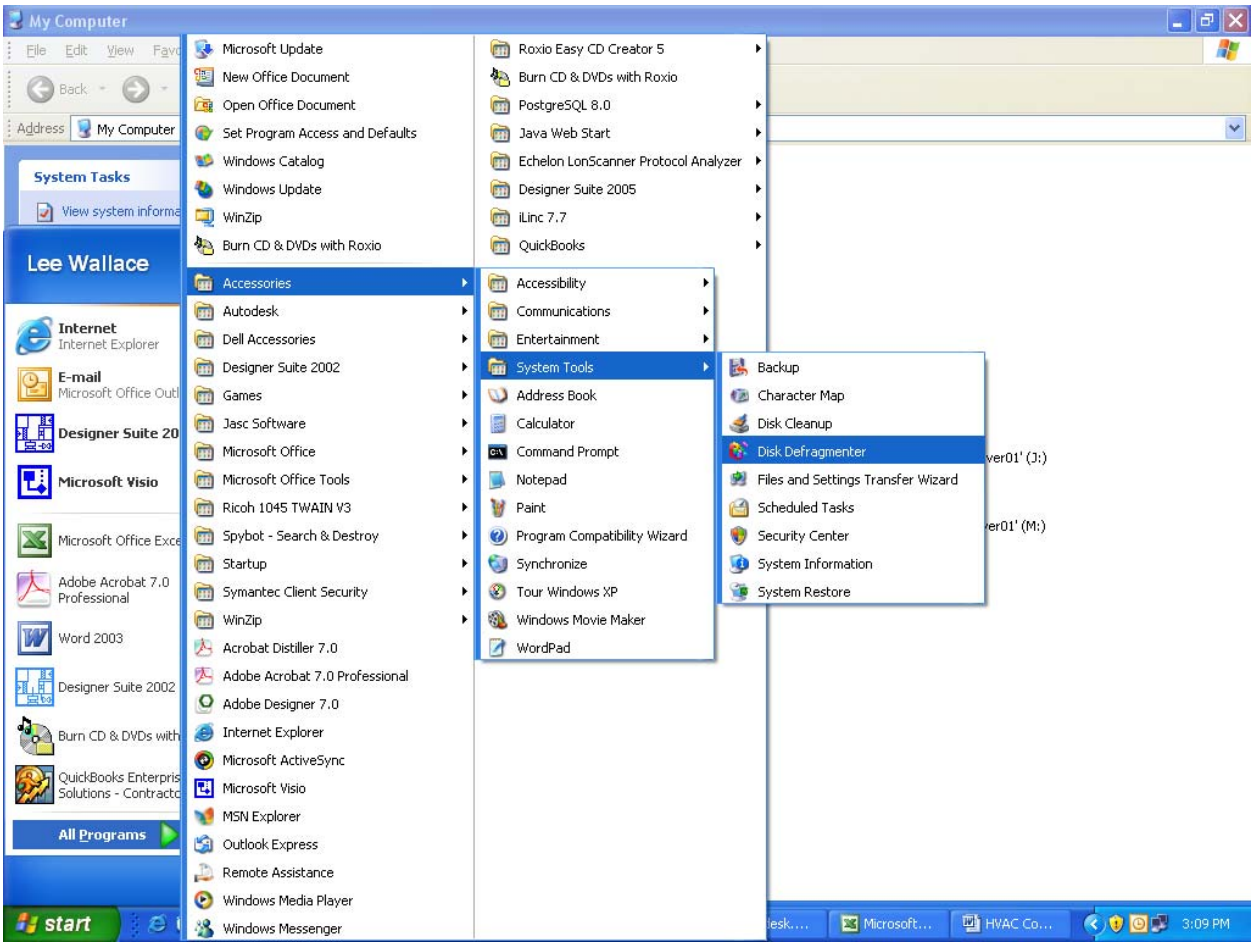
- Keep the HVAC Control System manuals and shop drawings nearby. It is recommended that operating personnel regularly refer to the system manuals and drawings in an effort to familiarize themselves with their contents and to increase system knowledge and reduce downtime during crisis situations. Typically 1 set is kept in the Building Engineer's office. Another set is typically installed by the Front End PC. A third set is usually kept offsite in a known secured location or other location as preferred by the customer.

System Maintenance

- The Front End PC Server should have the case opened up, and the interior blown out with compressed air annually. The power supply fans draw unfiltered air through the case on a continuous basis causing dust and dirt to buildup on the components inside the case. This should be done with care so as to not damage sensitive parts

- The Front End PC Server should have the hard drive degfragmented annually. There is typically a utility provided under the Windows operating system that performs this function. This process should be run during unoccupied hours as a safety precaution against system disruption. It is not uncommon for the defrag process to take hours – depending on the size of the hard drive and the amount of data storage on it. Reference the below screen capture for locating the "Disk Defragmenter" utility under a typical Windows XP operating system.

BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS



- System backups of the HVAC Control System software should be maintained on an ongoing basis. Backup discs were provided to the customer during system completion and turnover. However, as the system undergoes changes such as controller application changes, graphic screen modifications, controller binding table changes, address table changes, etc the system backups must be updated and kept current. System files reside in several locations. It is strongly recommended to have a trained authorized technician perform these backups as they are not always user friendly and at times require extensive knowledge and usage of specific software applications. In addition a strong knowledge of the DDC system software and hardware is necessary to know which software files need to be replaced after system changes are made. The building operator is typically not sufficiently qualified to perform system backups correctly.

- Anti-Virus and Spy ware software should be kept current on the Front End PC Server to protect the system from viruses, spy ware and other unwanted software that will negatively affect the performance of the system. It is recommended that the IT Manager get involved with this process as the Front End PC Server resides on the customers local area network and therefore should be treated as any other node on the network with respect to the requirements for Anti-Virus and Spy Ware software. It is also a good idea to remind the IT manager on an annual basis that the DDC Control system requires a fixed number of reserved static IP addresses and to make a note of those addresses so as to not assign those addresses to other nodes on the network. When two or more nodes on a network are assigned the same IP address, one or more nodes will experience communication failures over the network.

- Lubricate motorized dampers annually at the bearings. Clean all side seals with WD-40, Kroil, or similar cleaner/lubricant to prevent damper blades from binding. Inspect damper blades and linkages for

abnormalities, damage, and wear. With the damper in the closed position, make sure the blades are closed well enough to prevent excessive leakage. With damper blades in the fully open position, checks to make sure all blades are positioned consistently with respect to one another. If not, make adjustments as necessary.

- Critical temperature, pressure, humidity, and gas sensors should be calibrated annually. These may include sensors such as outside air, chilled water supply, hot water supply, steam pressure, primary and secondary loop supply and return water, duct static pressure, hot/chilled water system differential pressure, carbon monoxide, refrigerant gas, etc. Typically a testing device known to be accurate will take a measurement of the sensed media and compare it to the reading of the installed sensor. If the two readings are not close enough to meet satisfactory system performance, and offset calibration is made either to the device itself or in the DDC controller via software.

- Reference pages 5-8 of the Duct Smoke Detector Installation and Maintenance Instructions for information as to detector maintenance and testing. Test and maintain smoke detectors per requirements of NFPA 72. Typically the sampling tube filters need to cleaned annually and the detector chamber needs to be vacuumed and cleaned with compressed air. The detector should also be tested annually for proper operation per the manufacturer's instructions.

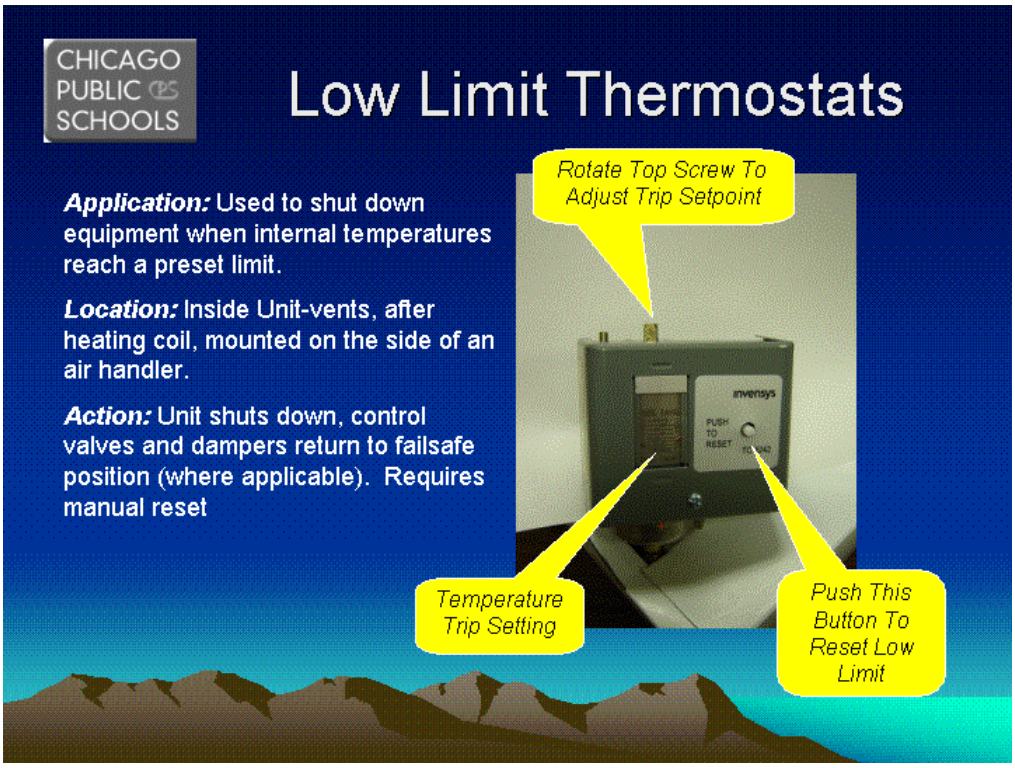
BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS

EXHIBIT F Sample Control Hardware Operation Instructions

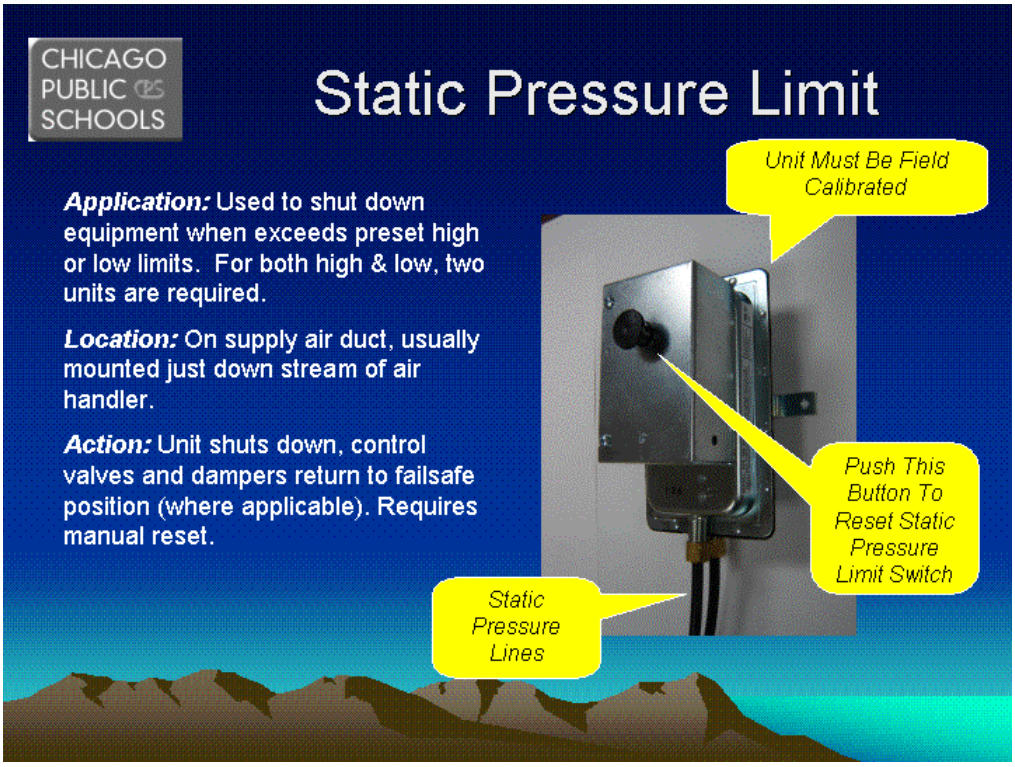
page 1

page 2

BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS

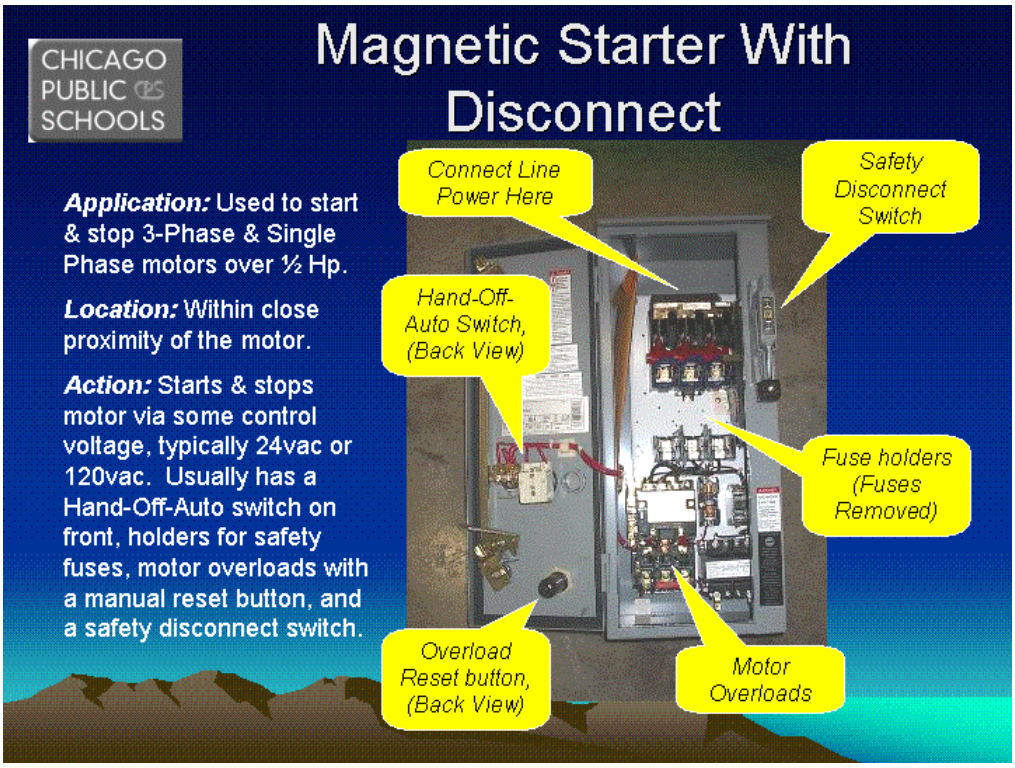


page 3

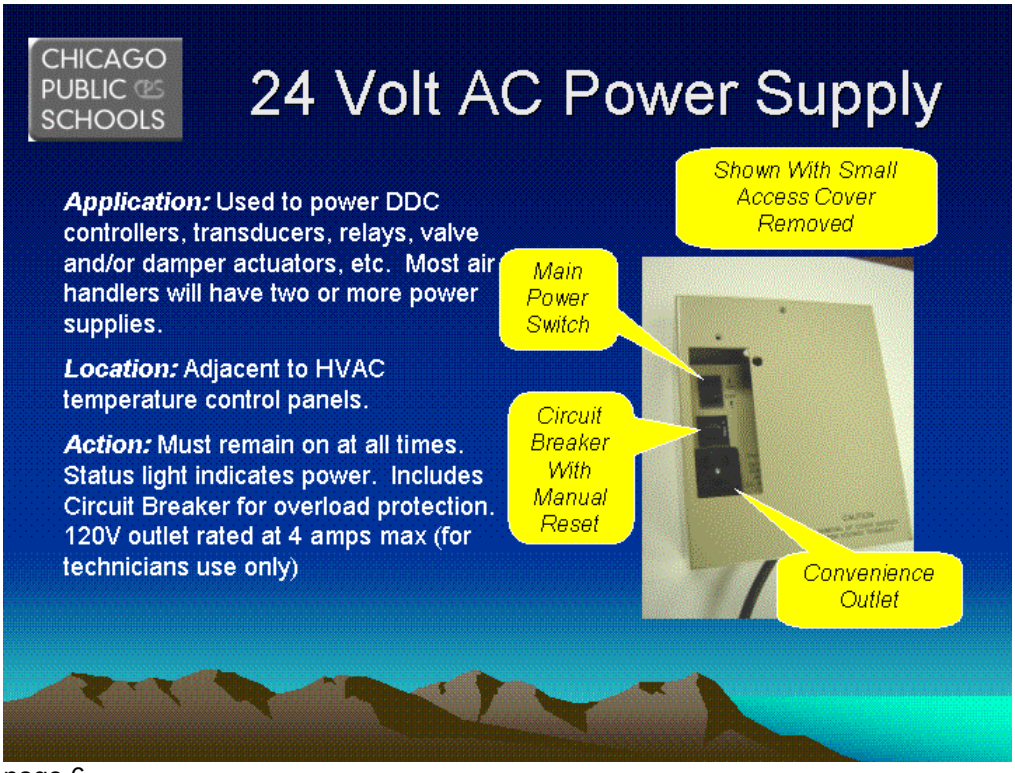


page 4

BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS

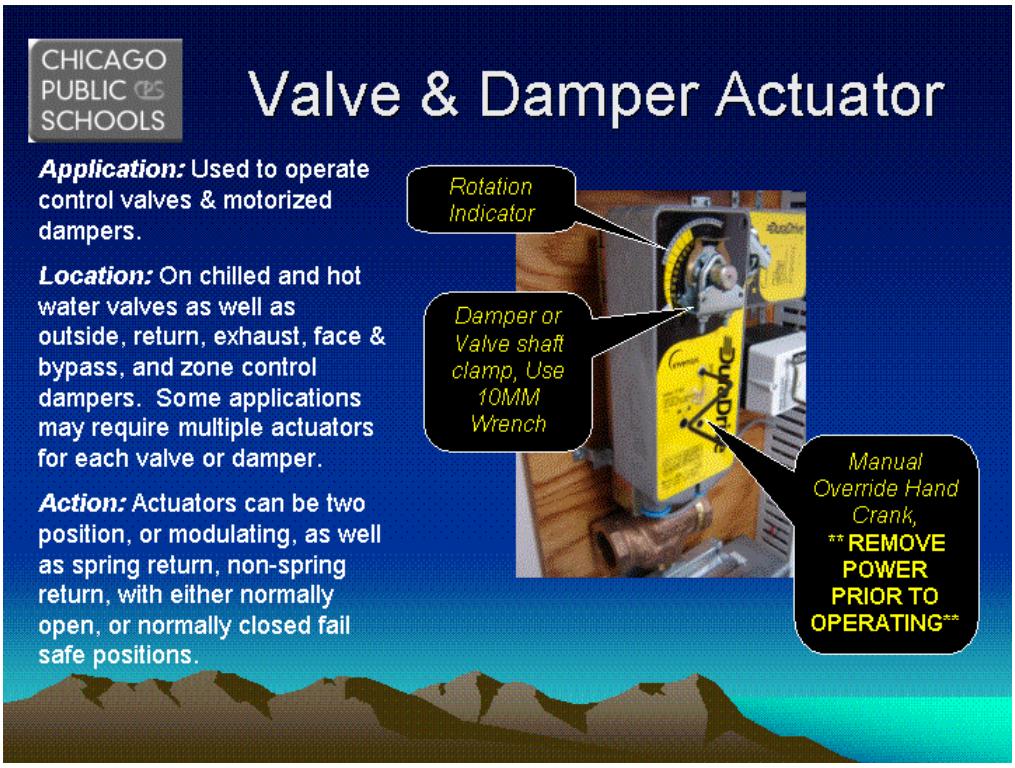


page 5

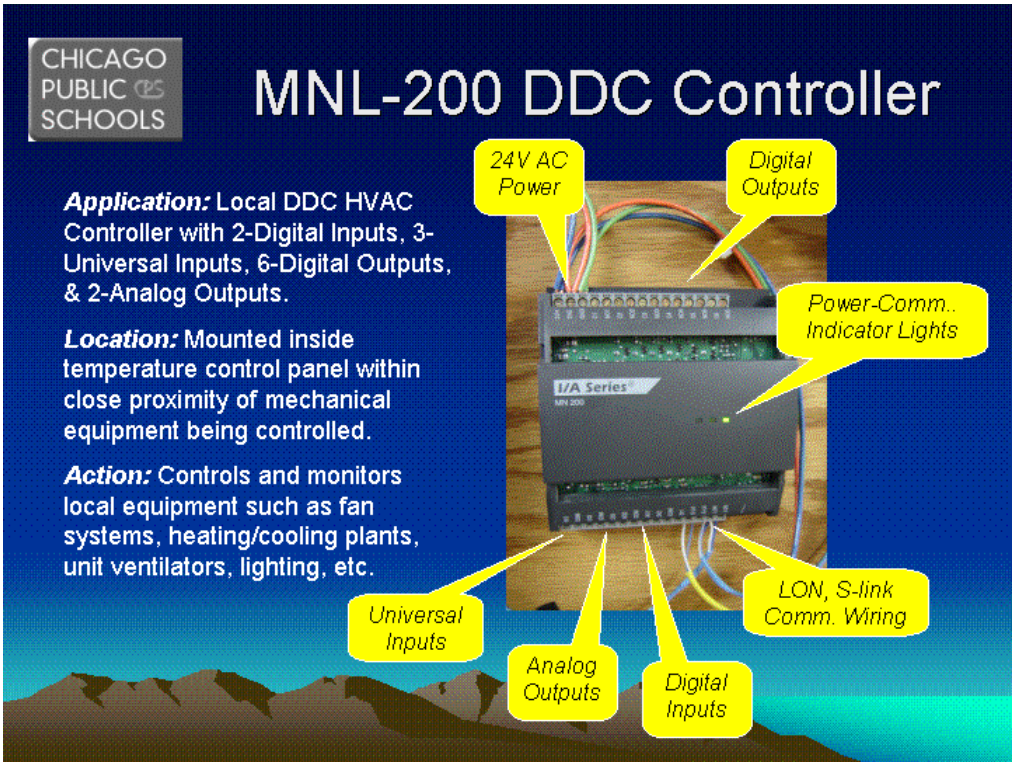


page 6

BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS



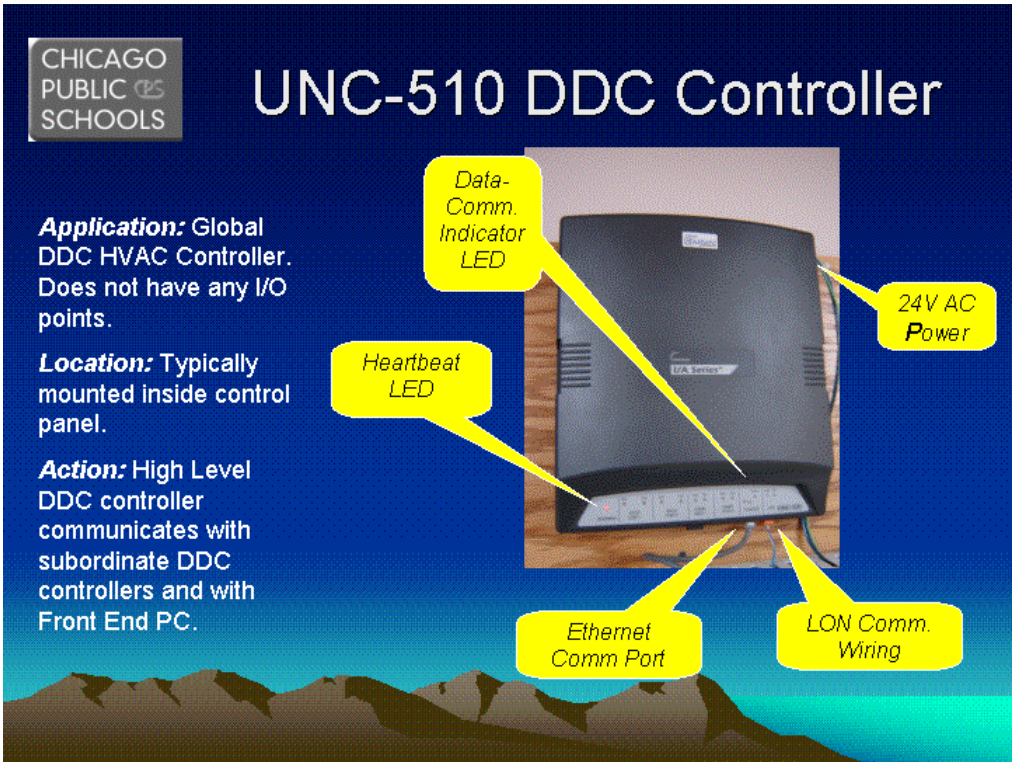
page 7



page 8

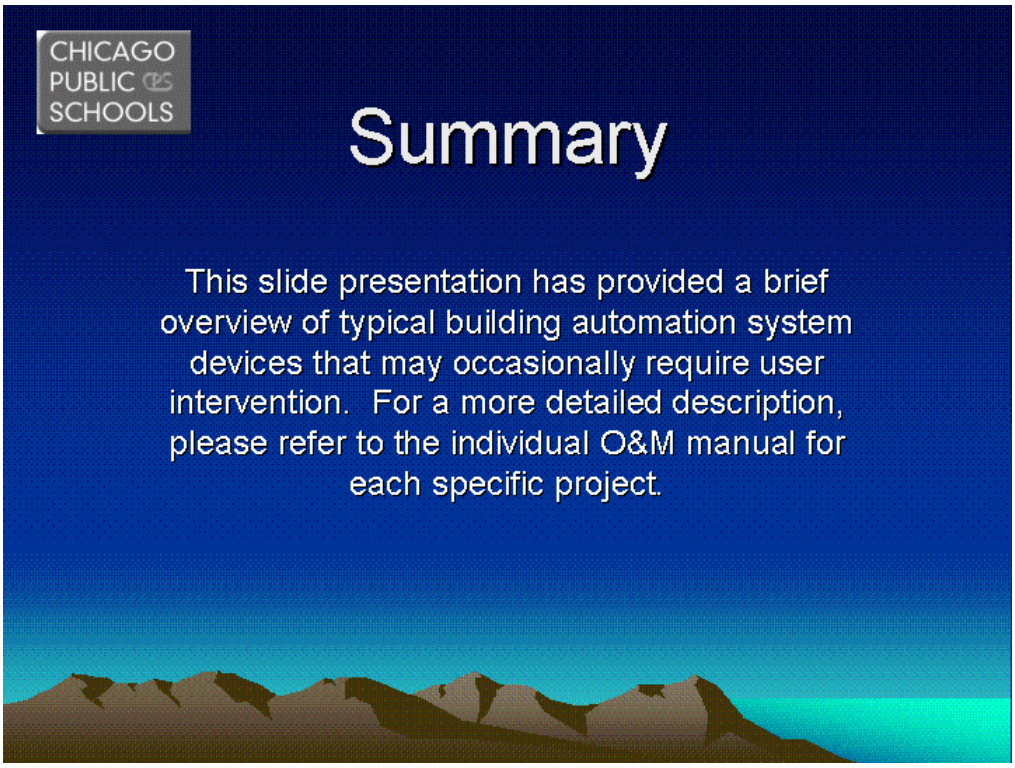
BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS

page 9



page 10

BUILDING AUTOMATION SYSTEM (BAS) – EXHIBITS



page 11

BUILDING AUTOMATION SYSTEM (BAS) - BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:
1. Wiring.
2. Control Valves and Actuators.
3. Control Dampers and Actuators.
4. Field Panels.
5. Sensors.
6. Flow Meter.
7. Electric Control Components (Switches, Thermostats, Relays, Smoke Detectors, etc.).
8. Transducers.
9. Air Flow Measuring Stations.
10. Current Switches.
11. Nameplates.
12. Testing Equipment.

1.2 DESCRIPTION OF WORK

A. Refer to Division 23 Section "Building Automation System (BAS)" for general requirements.

B. Refer to other Division 23 Sections for installation of instrument wells, valve bodies, and dampers in mechanical systems; not work of this Section.

C. Provide the following electrical work as work of this Section, complying with requirements of Division 26 Sections:
1. Control wiring between field-installed controls, indicating devices, and unit control panels.
2. Interlock wiring between electrically interlocked devices, sensors, and between a hand or auto position of motor starters as indicated for all mechanical and controls.
3. Wiring associated with indicating and alarm panels (remote alarm panels) and connections to their associated field devices.
4. All other necessary wiring for fully complete and functional control system as specified.
5. Power wiring from spare circuits in electrical panels to Digital Control System Field Panels.

1.3 WORK BY OTHERS

A. Control Valves furnished under this Section shall be installed under the applicable piping Section under the direction of the Digital Control System Contractor who will be fully responsible for the proper operation of the valve.

B. Control Dampers furnished under this Section shall be installed under the applicable air distribution or air handling equipment Section under the direction of the Digital Control System Contractor who will be fully responsible for the proper operation of the damper

C. Water Pressure Taps, Thermal Wells, Flow Switches, Flow Meters, etc. that will have wet surfaces, shall be installed under the applicable piping Section under the direction of the Digital Control System Contractor who will be fully responsible for the proper installation and application.

D. Controlled Equipment Power Wiring shall be furnished and installed under Division 26. Where control involves 120V control devices controlling 120V equipment, Division 26 Contractor shall extend power wiring to the equipment. Digital Control System Contractor shall extend it from the equipment to the control device.

BUILDING AUTOMATION SYSTEM (BAS) - BASIC MATERIALS,
INTERFACE DEVICES, AND SENSORS

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. General: Provide electronic control products in sizes and capacities indicated, consisting of valves, dampers, thermostats, clocks, controllers, sensors, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by manufacturer, and as required for application indicated.

B. Instrument Pipe and Tube
   1. Hydronic and Instruments
      a. Connection To Main Piping: Provide ½ inch minimum size threadolet, ½" x 2 inch brass nipple, and ½" ball valve for connection to welded steel piping. Provide tee fitting for other types of piping.
      b. Remote Instruments: Adapt from ball valve to specified tubing and extend to remote instruments. Provide a union or otherwise removable fitting at ball valve so that connection to main can be cleaned with straight rod. Where manifolds with test ports are not provided for instrument, provide tees with ¼" FPT branch with plug for use as test port. Adapt from tubing size to instrument connection.
      c. Line Mounted Instruments: Extend rigid piping from ball valve to instrument. Do not use close or running thread nipples. Adapt from ball valve outlet to instrument connection size. Provide a plugged tee if pipe makes 90 degree bend at outlet of valve to allow cleaning of connection to main with straight rod without removing instrument.
      d. Instrument Tubing: Seamless copper tubing, Type K or L, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22; or brass compression-type fittings. Solder shall be 95/5 tin antimony, or other suitable lead free composition solder. Tubing OD size shall be not less than the larger of ¼" or the instrument connection size.
      e. Rigid Piping For Line Mounted Instruments: Schedule 40 threaded brass, with threaded brass fittings.
   2. Low Pressure Air Instrument Sensing Lines
      a. Connections: Use suitable bulkhead type fitting and static sensing tip for static pressure connections. Adapt tubing to instrument connection.
      b. Tubing: Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, and with flame-retardant harness for multiple tubing. Use compression or push-on brass fittings.

C. Communication Wiring: All wiring shall be in accordance with National Electrical Codes and Division 26 of this specification.
   1. Contractor shall supply all communication wiring between Building Controllers (BC), Routers, Gateways, Advanced Application Controllers (AAC), Application Specific Controllers (ASC) and local and remote peripherals (e.g., operator workstations, printers, and modems).
   2. Local Supervisory LAN: For any portions of this network required under this Section of the specification, contractor shall use Fiber or Category 5 of standard TIA/EIA 68 (10BaseT). Network shall be run with no splices and separate from any wiring over thirty (30) volts.
   3. Primary and Secondary Controller LANs: Communication wiring shall be individually 100% shielded pairs per manufacturers recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any wiring over thirty (30) volts. Shield shall be terminated and wiring shall be grounded as recommended by BC manufacturer.

D. Signal Wiring: Contractor shall run all signal wiring in accordance with National Electric Codes and Division 26 of this Specification.

1. Signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, etc. shall be twisted, 100% shielded pair, minimum 18-gauge wire, with PVC cover. Signal wiring shall be run with no splices and separate from any wiring above thirty (30) volts.
2. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.

E. Low Voltage Analog Output Wiring: Contractor shall run all low voltage control wiring in accordance with National Electric Codes and Division 26 of this Specification.
1. Low voltage control wiring shall be minimum 16-gauge, twisted pair, 100% shielded, with PVC cover, Class 2 plenum-rated. Low voltage control wiring shall be run with no splices separate from any wiring above thirty (30) volts.

F. Control Panels: Provide control panels with suitable brackets for wall mounting for each control system. Locate panel adjacent to systems served.
1. Fabricate panels of 16-gage furniture-grade steel, or 6063-T5 extruded aluminum alloy, totally enclosed on four sides, with hinged door and keyed lock, with manufacturer's standard shop- painted finish and color.
2. Provide UL-listed cabinets for use with line voltage devices.
3. All gauges and control components shall be identified by means of nameplates.
4. All control tubing and wiring shall be run neatly and orderly in open slot wiring duct with cover.
5. Complete wiring and tubing termination drawings shall be mounted in or adjacent to panel.

2.2 Control Valves

A. General: Provide factory fabricated control valves of type, body material and pressure class indicated. Where type or body material is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature in piping system. Provide valve size in accordance with scheduled or specified maximum pressure drop across control valve. Where not specified, maximum pressure drop across control valve shall be 5ftwc at design flow rate. Control valves shall be equipped with heavy-duty actuators, and with proper close-off rating for each individual application. Minimum close-off rating shall be as scheduled and adequate for each application, and shall generally be considered at dead head rating of the pump.

B. Plug-Type Globe Pattern for Water Service:
1. Valve Sizing: Where not specifically indicated on the control drawings, modulating valves shall be sized for maximum full flow pressure drop between 50% and 100% of the branch circuit it is controlling unless scheduled otherwise. Two-position valves shall be same size as connecting piping.
2. Single Seated (Two-way) Valves: Valves shall have equal-percentage characteristic for typical heat exchanger service and linear characteristic for building loop connections to campus systems unless otherwise scheduled on the drawings. Valves shall have cage-type trim, providing seating and guiding surfaces for plug on ‘top-and-bottom’ guided plugs.
3. Double Seated (Three-way) Valves: Valves shall have linear characteristic. Valves shall be balanced-plug type, with cage-type trim providing seating and guiding surfaces on ‘top-and-bottom’ guided plugs.
4. Temperature Rating: 25°F minimum, 250°F maximum
5. Body: Bronze, screwed, 250 psi maximum working pressure for 1/2” to 2”; Cast Iron, flanged, 125 psi maximum working pressure for 2-1/2” and larger.
6. Valve Trim: Bronze; Stem: Polished stainless steel.
7. Packing: Spring Loaded Teflon or Synthetic Elastomer U-cups, self-adjusting.
8. Plug: Brass, bronze or stainless steel, Seat: Brass
9. Disc: Replaceable Composition or Stainless Steel Filled PTFE.
10. Ambient Operating Temperature Limits: -10 to 150°F

11. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
    a. Johnson Controls
    b. Invensys
    c. Warren
    d. Delta
    e. Belimo

C. Butterfly Type: Valve will be sized for 50 to 100% of branch pressure drop. For valves sized at 3way less than 90 degree position for pressure drop are to have the linkage for full closed when the open port is at the design point.
1. Body: Extended neck epoxy coated cast or ductile iron with full lug pattern, ANSI Class 125 or 250 bolt pattern to match specified flanges.
2. Seat: EPDM, except in loop bypass applications where seat shall be metal to metal
3. Disc: Bronze or stainless steel, pinned or mechanically locked to shaft
4. Bearings: Bronze or stainless steel
5. Shaft: 416 stainless steel
6. Cold Service Pressure: 175 psi
7. Close Off: Bubble-tight shutoff to 150 psi
8. Operation: Valve and actuator operation shall be smooth both seating and unseating. Should more that 2 psi deadband be required to seat/unseat the valve, valve shall be replaced at no cost to the Government.
9. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
    a. Jamesbury WS815
    b. Bray Series 31
    c. Belimo

D. Ball Type: Valve will be sized for 50 to 100% of branch pressure drop.
1. Body: Brass or bronze; one-, two-, or three-piece design; threaded ends.
2. Seat: Reinforced Teflon
3. Ball: Stainless steel.
4. Port: Standard or ‘V’ style.
5. Stem: Stainless steel, blow-out proof design, extended to match thickness of insulation.
6. Cold Service Pressure: 600 psi WOG
7. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
    a. Belimo
    b. Jamesbury
    c. Delta

E. Segmented or Characterized Ball Type
1. Body: Carbon Steel (ASTM 216), one-piece design with wafer style ends.
2. Seat: Reinforced Teflon (PTFE).
3. Ball: Stainless steel ASTM A351
4. Port: Segmented design with equal-percentage characteristic.
5. Stem: Stainless steel.
6. Cold Service Pressure: 200 psi WOG
7. Cavitation Trim: Provide cavitation trim where indicated and/or required, designed to eliminate cavitation and noise while maintaining an equal percentage characteristic. Trim shall be a series of plates with orifices to break the pressure drop into multi-stages.
8. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
    a. Jamesbury R-Series
    b. Fisher

c. Belimo

2.3 Control Dampers

A. General: Provide factory fabricated automatic control dampers of sizes, velocity and pressure classes as required for smooth, stable, and controllable air flow. Provide parallel or opposed blade dampers as recommended by manufacturers sizing techniques. Provide parallel blade dampers for dampers providing two-position control (for multi zone dampers a parallel blade application with lower torque requirements should be submitted as an alternate). For dampers located near fan outlets, provide dampers rated for fan outlet velocity and close-off pressure, and recommended by damper manufacturer for fan discharge damper service.

B. For zone dampers and other applications with duct or opening areas less that 5 square feet that do not provide isolation to out doors and function in a general isolation and modulating control service in rectangular ducts at velocities not greater than 1500 fpm , differential pressure not greater than 2.5" w.c.:
1. Performance: Test in accordance with AMCA 500.
2. Frames: Galvanized steel, 16-gauge minimum thickness, welded or riveted with corner reinforcement.
3. Blades: Stainless steel in lab exhausts and galvanized steel elsewhere, maximum blade size 8 inches wide by 48 inches long, attached to minimum 1/2 inch shafts with set screws, 16 gauge minimum thickness.
4. Blade Seals: Synthetic elastomer, mechanically attached, field replaceable.
5. Jamb Seals: None.
6. Shaft Bearings: Oil impregnated sintered bronze, graphite impregnated nylon sleeve or other molded synthetic sleeve, with thrust washers at bearings.
7. Linkage: Concealed in frame if parallel.
8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
9. Leakage: Less than one percent based on approach velocity of 1500 ft./min. and 1 inch wg.
10. Maximum Pressure Differential: 2.5 inches wg.
11. Temperature Limits: -40 to 200 °F.
12. Where two dampers are to be mechanically interlocked such as a face and bypass arrangement, the manufacturer will provide required torque values for the combined damper assembly.
13. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
    a. Johnson Controls D-1100
    b. Ruskin CD36
    c. Vent Products 5800

C. For applications with duct or opening areas greater than 5 square feet that do not provide isolation to out doors and function in a general isolation and modulating control service in rectangular ducts at velocities exceeding 1500 fpm , differential pressure greater than 2.5" w.c.:
1. Performance: Test in accordance with AMCA 500.
2. Frames: Galvanized steel, 16-gauge minimum thickness, welded or riveted with corner reinforcement.
3. Blades: Galvanized steel or extruded aluminum hollow airfoil shape, maximum blade size 8 inches wide by 48 inches long, attached to minimum 1/2 inch shafts, 14 gauge minimum extrusion thickness.
4. Blade Seals: Synthetic elastomeric, mechanically attached, field replaceable.
5. Jamb Seals: Stainless steel.
6. Shaft Bearings: Oil impregnated sintered bronze sleeve, graphite impregnated nylon sleeve, molded synthetic sleeve, or stainless steel sleeve, with thrust washers at bearings.
7. Linkage: Concealed in frame if parallel.
8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.

9. Leakage: Less than 0.1 percent based on approach velocity of 4000 ft./min. and 1 inch wg. .
10. Maximum Pressure Differential: 6 inches wg.
11. Temperature Limits: -40 to 200 °F.
12. Where opening size is larger than 48 inches wide, or 72 inches high, provide dampers in multiple sections, with appropriately intermediate frames, and jackshafts. For multiple dampers driven by a jackshaft the shaft will rigid in torsion and driven by at least two actuators located at either end of the shaft.
13. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
    a. TAMCO 1000
    b. Ruskin CD60
    c. CESCO Products AGA or AGB

D. For all outside air intake or exhaust control dampers that provide isolation to out doors or otherwise need to provide thermal isolation:
1. Performance: Test in accordance with AMCA 500.
2. Frames: Galvanized steel, 16-gauge minimum thickness, welded or riveted with corner reinforcement.
3. Blades: Extruded aluminum hollow airfoil shape, maximum blade size 8 inches wide by 48 inches long, attached to minimum 1/2 inch shafts, 14 gauge minimum extrusion thickness.
4. Blade Seals: Synthetic elastomeric, mechanically attached, field replaceable.
5. Jamb Seals: Non-metallic seal.
6. Shaft Bearings: Oil impregnated sintered bronze sleeve, graphite impregnated nylon sleeve, molded synthetic sleeve, or stainless steel sleeve, with thrust washers at bearings.
7. Linkage: Concealed in frame if parallel.
8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
9. Leakage: Less than 0.1 percent based on approach velocity of 4000 ft./min. and 1 inch wg. .
10. Maximum Pressure Differential: 6 inches wg.
11. Temperature Limits: -40 to 200 °F.
12. Where opening size is larger than 48 inches wide, or 72 inches high, provide dampers in multiple sections, with appropriately intermediate frames, and jackshafts. For multiple dampers driven by a jackshaft the shaft will rigid in torsion and driven by at least two actuators located at either end of the shaft.
13. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
    a. TAMCO 9000
    b. Ruskin CDTI50
14. For general isolation and modulating control service in round ducts up to 40 inches in size at velocities not greater than 2500 fpm , differential pressure not greater than 4” w.c.:
15. Performance: Test in accordance with AMCA 500.
16. Frames: rolled 12 gauge steel strip for sizes 6 inch and smaller, rolled 14 gauge steel channel for larger sizes, galvanized or aluminum finish.
17. Blades: Steel construction, 12 gauge minimum thickness for dampers less than 18 inches in size, 10 gauge minimum thickness for larger dampers.
18. Blade Seals: Full circumference neoprene.
19. Shaft: ½ inch diameter zinc or cadmium plated steel.
20. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
21. Leakage: Less than 0.2 percent based on approach velocity of 4000 ft./min. and 1 inch wg. differential pressure.
22. Maximum Pressure Differential: 4 inches wg.
23. Temperature Limits: -40 to 300 °F.

E. For general isolation and modulating control service in round ducts up to 60 inches in size at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 6" w.c. (1492 Pa):
   1. Performance: Test in accordance with AMCA 500.
   2. Frames: rolled 10-gauge steel channel for sizes 48 inch and smaller, rolled 3/16 inch thick steel channel for larger sizes, galvanized or aluminum finish.
   3. Blades: Steel construction, 10-gauge minimum thickness for dampers not greater than 48 inches in size, ¼ inch minimum thickness for larger dampers.
   4. Blade stops: ½ inch x ¼ inch full circumference steel bar.
   5. Blade Seals: Full circumference neoprene.
   6. Shaft: zinc or cadmium plated steel, angle reinforcing as necessary.
   7. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
   8. Leakage: Less than 0.4 percent based on approach velocity of 4000 ft./min. and 1 inch wg. differential pressure.
   9. Maximum Pressure Differential: 6 inches wg.
   10. Temperature Limits: -40 to 250 °F.

2.4 ACTUATORS

A. General: Size actuators and linkages to operate their appropriate dampers or valves with sufficient reserve torque or force to provide smooth modulating action or 2-position action as specified. Select spring-return actuators with manual override to provide positive shut-off of devices as they are applied.

B. Damper Actuators
   1. Ambient Operating Temperature Limits: -10 to 122°F
   2. Two Position Electric Actuators: Line voltage with spring return
   3. Electronic Actuators: Provide actuators with spring return for two-position (24v), 0-5 Vdc, 0-10 Vdc, 2-10Vdc, 4-20 mA, as required. Actuators shall travel full stroke in less than 90 seconds, unless prior approval is obtained. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed. Provide stroke indicator. Actuators shall have positive positioning circuit. Where two actuators are required in parallel, or in sequence, provide an auxiliary actuator driver. Actuators shall have current limiting motor protection. Actuators shall have manual override . Modulating actuators for valves shall have minimum rangeability of 40 to 1.
      a. Close-Off Pressure: Provide the minimum torque required, and spring return for fail positioning (unless otherwise specifically indicated) sized for required close-off pressure. Required close-off rating of air damper applications shall be shutoff pressure of associated fan, plus 10 percent. When shutoff does not apply the actuator will be sized based on the manufactures required torque plus 30%.
      b. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
         1) Belimo
         2) Delta
         3) Invensys

C. Quarter-Turn Actuators (for ball and butterfly valves):
   1. Electric
      a. Motor: Suitable for 120 or 240 Volt single-phase power supply. Insulation shall be NEMA Class F or better. Motor shall be rated for 100 percent duty cycle. Motors shall have inherent overload protection.
      b. Gear Train. Motor output shall be directed to a self locking gear drive mechanism. Gears shall be rated for torque input exceeding motor locked rotor torque.
      c. Wiring: Power and control wiring shall be wired to a terminal strip in the actuator enclosure

d. Failsafe Positioning: Actuators shall be spring return type for failsafe positioning.
e. Enclosure: Actuator enclosure shall be NEMA-4 rated, and shall have a minimum of two threaded conduit entries. Provide an enclosure heater for actuators located outside of buildings.
f. Limit Switches: Travel limit switches shall be UL and CSA approved. Switches shall limit actuator in both open and closed positions.
g. Mechanical Travel Stops: The actuator shall include mechanical travel stops of stainless steel construction to limit actuator to specific degrees of rotation.
h. Manual Override: Actuators shall have manual actuator override to allow operation of the valve when power is off. For valves 4 inches and smaller the override may be a removable wrench or lever or geared handwheel type. For larger valves, the override shall be a fixed geared handwheel type. An automatic power cut-off switch shall be provided to disconnect power from the motor when the handwheel is engaged for manual operation.
i. Valve Position Indicator: A valve position indicator with arrow and open and closed position marks shall be provided to indicate valve position.
j. Torque Limit Switches: Provide torque limit switches to interrupt motor power when torque limit is exceeded in either direction of rotation.
k. Position Controller: For valves used for modulating control, provide an electronic positioner capable of accepting 4-20 mA, 0-10 Vdc, 2-10 Vdc, and 135 Ohm potentiometer.
l. Ambient Conditions: Actuator shall be designed for operation from –10 to 150 °F ambient temperature with 0 to 100 percent relative humidity.

2.5 GENERAL FIELD DEVICES

A. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers, and as required for proper operation in the system.

B. It shall be the Contractor's responsibility to assure that all field devices are compatible with controller hardware and software.

C. Field devices specified herein are generally ‘two-wire’ type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, or is not designed to work with ‘two-wire’ type transmitters, or if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, the Contractor shall provide ‘four-wire’ type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.

D. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.

E. Accuracy: As stated in this Section, accuracy shall include combined effects of nonlinearity, nonrepeatability and hysteresis.

F. Provide controllers and field panels with minimum 10% spare points capacity for AI/AO/DI/DO.

2.6 TEMPERATURE SENSORS (TS)

A. Sensor range: When matched with A/D converter of BC, AAC/ASC, or Smart Sensor (SS), sensor range shall provide a resolution of no worse than 0.3°F (unless noted otherwise). Where thermistors are used, the stability shall be better than 0.25°F over 5 years.

B. Matched Sensors: The following applications shall require matched sensors:
1. Building Loop Connections: Provide matched loop and building supply sensors where control sequence requires controlling to a temperature rise (differential).

2. Hydronic Temperature Difference Calculations: Provide matched supply and return temperature sensors where the pair is used for calculating temperature difference for use in load calculations or sequencing such as across chillers and plants.
3. Air Handling Unit Sequencing: Provide matched pair for the cooling and heating coil leaving sensors where the sequence includes calculating an offset from the supply air setpoint to maintain a leaving heating coil temperature.

C. Room Temperature Sensor: Shall be a stainless steel wall plate sensor. An electronic thermostat with manual slide adjustment will be provided as noted on the drawings. Provide ¼" medical grade closed cell foam insulating material. The following sensing elements are acceptable:
1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.3°F accuracy at calibration point.

D. Single-Point Duct Temperature Sensor: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range as required for resolution indicated in paragraph A. Sensor probe shall be 316 stainless steel.
1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.3°F accuracy at calibration point

E. Averaging Duct Temperature Sensor: Shall consist of an averaging element, junction box for wiring connections and gasket to prevent air leakage. Provide sensor lengths and quantities to result in one lineal foot of sensing element for each three square feet of cooling coil/duct face area. Temperature range as required for resolution indicated in paragraph A.
1. Sensing element shall be platinum RTD, or thermistor, +/- 0.3°F accuracy at calibration point.

F. Liquid immersion temperature sensor shall include thermowell, sensor and connection head for wiring connections. Provide thermally conductive paste in well to ensure good contact with the well. Temperature range shall be as required for resolution of 0.15°F.
1. Sensing element (chilled water/glycol systems) shall be platinum RTD +/- 0.2°F accuracy at calibration point. Temperature range shall be as required for resolution of 0.15°F.
2. Sensing element (other systems) shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point. Temperature range shall be as required for resolution of 0.3°F.

G. Pipe Surface-Mount Temperature Sensor: Sensor are only for use in applications specifically identified on the drawings. Shall include metal junction box and clamps and shall be suitable for sensing pipe surface temperature and installation under insulation. Provide thermally conductive paste at pipe contact point. Temperature range shall be as required for resolution indicated in paragraph A.
1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.

H. Outside air sensors shall consist of a sensor, an aspirated enclosure, utility box, and watertight gasket to prevent water seepage. Temperature range shall be as required for resolution indicated in Paragraph A
1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.
2. Acceptable Manufacturers: Kele A21 or equal

2.7 Temperature Transmitters

A. Where required by Controller, or where wiring runs are over 50 feet, sensors as specified above may be matched with transmitters outputting 4-20 mA linearly across the specified temperature range. Transmitters shall have zero and span adjustments, an accuracy of 0.1°F when applied to the sensor range.

BUILDING AUTOMATION SYSTEM (BAS) - BASIC MATERIALS,
INTERFACE DEVICES, AND SENSORS

2.8 HUMIDITY TRANSMITTERS

A. Units shall be suitable for duct, wall (room) or outdoor mounting. Unit shall be two-wire transmitter utilizing bulk polymer resistance change or thin film capacitance change humidity sensor. Unit shall produce linear continuous output of 4-20 mA for percent relative humidity (% RH). A combination temperature and humidity sensor may be used for zone level monitoring. Sensors shall have the following minimum performance and application criteria:
   1. Input Range: 0 to 100% RH.
   2. Accuracy (% RH): +/- 2% (when used for enthalpy calculation, dewpoint calculation or humidifier control) or +/- 3% (monitoring only) between 20-90% RH at 77°F, including hysteresis, linearity, and repeatability.
   3. Sensor Operating Range: As required by application
   4. Long Term Stability: Less than 1% drift per year.

B. Acceptable Manufacturers: Units shall be Vaisala HM Series, General Eastern, Microline, or Hy-Cal HT Series, Kele H_20K.

2.9 Pressure and DIFFERENTIAL PRESSURE TRANSMITTERS (DP)

A. General Purpose - Water: Two-wire transmitter, 4-20 mA output with zero and span adjustments. Plus or minus 0.5% overall accuracy, 450 psig maximum static pressure rating, 200 psid maximum overpressure rating for 6 through 60 psid range, 450 psid for 100 through 300 psid range.
   1. Acceptable units shall be Kele & Associates Model 360 C

B. Liquid and Gas:
   1. General: Two-wire smart DP cell type transmitter, 4-20 mA or 1-5 Vdc user-selectable linear or square root output, adjustable span and zero, stainless steel wetted parts.
   2. Environmental limits: –40 to 250 °F , 0 to 100% RH..
   3. Accuracy: less than 0.1 percent of span.
   4. Output Damping: Time constant user selectable from 0 to 36 seconds.
   5. Vibration Effect: Less than ±0.1% of upper range limit from 15 to 2000 Hz in any axis relative to pipe mounted process conditions.
   6. Electrical Enclosure: NEMA-4, -4X, -7, -9.
   7. Approvals: FM, CSA.
   8. Acceptable Manufacturers: Rosemount Inc. 3051 Series, Foxboro, Johnson-Yokagawa, Setra, or Mamac.

C. General Purpose Low Pressure Air: Generally for use in static measurement of duct pressure or constant volume air velocity pressure measurement where the range is applicable.
   1. General: Loop powered two-wire differential capacitance cell-type transmitter.
   2. Output: two wire 4-20 mA output with zero adjustment.
   3. Overall Accuracy: Plus or minus 1% of reading.
   4. Minimum Range: 0.1 in. w.c.
   5. Maximum Range: 10 inches w.c.
   6. Housing: Polymer housing suitable for surface mounting.
   7. Acceptable Manufacturers: Modus T30.
   8. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
   9. Range: Select for specified setpoint to be between 25% and 75% full-scale.

D. General Purpose Low Pressure/Low Differential Air: Generally for use in static measurement of space pressure or constant volume air velocity pressure measurement where the range is applicable.
   1. General: Loop powered, two-wire differential capacitance cell type transmitter.
   2. Output: Two-wire 4-20 mA output with zero adjustment.
   3. Overall Accuracy: Plus or minus 1% of reading.
   4. Minimum Range: 0 in. w.c.

5. Maximum Range: 0.1, 0.25, or 0.5 inches w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Acceptable Manufacturers: Modus T30 or Setra.
8. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
9. Range: Select for specified setpoint to be between 25% and 75% full-scale.

E. Velocity Pressure: Generally for use in air velocity pressure measurement where the range is applicable.
1. General: Loop powered two-wire differential capacitance cell type transmitter.
2. Output: Two-wire, 4-20 mA output with zero adjustment.
3. Overall Accuracy: Plus or minus 0.25%
4. Minimum Range: 0 in. w.c.
5. Maximum Range: 1 inch w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Acceptable Manufacturers: Setra 264 with optional FS accuracy above or equal. .
8. Range: Select for minimum range that will accept the maximum velocity pressure expected.

2.10 Valve Bypass for Differential Pressure Sensors

A. Provide a five valve bypass kit for protection of DP sensors where the static on the pipe can cause on over pressure when connected to one port with the other at atmospheric pressure. Kit shall include high and low pressure isolation valves, high and low pressure vent valves, and a bypass valve contained in a NEMA-1 enclosure.

2.11 DIFFERENTIAL PRESSURE SWITCHES (DPS)

A. General Service - Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Provide manufacturer's recommended static pressure sensing tips and connecting tubing

B. General Service - Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential, and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range. 0°F to 160°F operating temperature range.

2.12 PRESSURE SWITCHES (PS)

A. Diaphragm or bourdon tube with adjustable setpoint and differential and snap-acting Form C contacts rated for the application. Pressure switches shall be capable of withstanding 150% of rated pressure.

B. Acceptable Manufacturers: Square D, ITT Neo-Dyn, ASCO, Penn, Honeywell, and Johnson Controls.

2.13 TRANSDUCERS

A. Binary to Analog Transducers or Tri-State-to-Voltage or -Current:
1. Adjustable zero and span.
2. Failure Mode on Power Loss: Shall be provided with memory feature to allow the transducer to return to last value on power failure.
3. Accuracy: ± 1% of span
4. Output Span: 4-20 mA, 0-5 Vdc, 1-5 Vdc, 0-10Vdc, 2-10Vdc, 0-15Vdc, 3-15Vdc
5. Input: 4-20 mA, pulse width modulated or tri-state input.
6. Tri-state Input Time Base: Dip switch selectable.
7. Enclosure: Polymer designed for surface or panel mount.
8. Failure Mode on Power Loss: Non-failsafe transducers shall have no output air loss. Failsafe transducers shall exhaust output upon power loss.
9. Acceptable Manufacturers: RE Technologies Model PWA Series.

B. Electronic-to Electronic (Voltage or Current to Current or Voltage):

1. Adjustable zero and span.
2. Failure Mode on Power Loss: Memory feature to allow the transducer to return to last value on power failure.
3. Accuracy: ± 1% of span.
4. Output Span: 4-20 mA, 0-5 Vdc, 1-5 Vdc, 0-10 Vdc, 2-10 Vdc, 0-15 Vdc, 3-15 Vdc.
5. Input: 0-20 Vdc, 0-20 ma, 0-10 kOhm.
6. Enclosure: Polymer enclosure designed for surface or panel mount.
7. Acceptable Manufacturers: RE Technologies Model PWA Series.

2.14 Current Switches (CS)

A. Clamp-On or Solid-Core Design Current Operated Switch (for Constant Speed Motor Status Indication)
   1. Range: 1.5 to 150 amps.
   2. Trip Point: Adjustable.
   3. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage.
   4. Lower Frequency Limit: 6 Hz.
   5. Trip Indication: LED
   6. Approvals: UL, CSA
   7. Max. Cable Size: 350 MCM
   8. Acceptable Manufacturers: Veris Industries H-708/908; Inc., RE Technologies SCS1150A-LED.

B. Clamp-on or Solid-Core Wire Through Current Switch (CS/CR) (for Constant Speed Motors): Same as CS with 24v command relay rated at 5A @ 240 Vac resistive, 3A @ 240 Vac inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A). Acceptable Manufacturers shall be Veris Industries, Inc., Model # H938/735; or RE Technologies RCS 1150.
   1. Where used for single-phase devices, provide the CS/CR in a self-contained unit in a housing similar with override switch to Kele RIBX.

C. Clamp-On Design Current Operated Switch for Variable Speed Motor Status Indication
   1. Range: 1.5 to 135 Amps.
   2. Trip Point: Self-calibrating based on VA memory associated with frequency to detect loss of belt with subsequent increase of control output to 60 Hz.
   3. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage.
   4. Frequency Range: 5-75 Hz
   5. Trip Indication: LED
   6. Approvals: UL, CSA
   7. Max. Cable Size: 350 MCM
   8. Acceptable Manufacturers: Veris Industries, Inc. H-904.

D. Clamp-On Wire Through Current Switch (CS/CR) (for Variable Speed Motors): Same as CS with 24v command relay rated at 5A @ 240 Vac resistive, 3A @ 240 Vac inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A). Acceptable manufacturer shall be Veris Industries, Inc., Model # H934.

E. Variable Speed Status: Where current switches are used to sense the status for variable speed devices, the CT shall include on-board VA/Hz memory to allow distinction between a belt break and subsequent ramp up to 60 Hz, versus operation at low speed. The belt break scenario shall be indicated as a loss of status and the operation at low speed shall indicate normal status.

2.15 CURRENT TRANSFORMERS (CT)

A. Clamp-On Design Current Transformer (for Motor Current Sensing)

1. Range: 1-10 amps minimum, 20-200 amps maximum
2. Trip Point: Adjustable
3. Output: 0-5 VDC.
4. Accuracy: ±0.2% from 20 to 100 Hz.
5. Acceptable Manufacturers: KELE SA100, Veris Hawkeye 720.

2.16 OUTDOOR AIR STATIC PRESSURE SENSING TIP

A. Pressure sensor: Pressure sensing tip shall be designed to minimize the effects of wind and resulting velocity pressure up to 80 mph. Acceptable manufacturers shall be Dwyer A-306.

B. Low Air Pressure Surge Dampener: 30-second time constant. Acceptable manufacturer shall be Modus SD030.

2.17 CONTINUOUS LEVEL TRANSMITTERS

A. Capacitance Type
1. Provide a loop powered, continuous capacitance type level transmitter with adjustable span and zero.
2. Output: 4-20 mA.
3. Probe: Fluoropolymer coated stainless steel rod or cable. Provide cable probe with end attachment hardware or weight.
4. Electrical Enclosure: NEMA-4, -7.
5. Approvals: UL or CSA.
6. Accuracy: ±1% of calibrated span.
7. Process Connection: MPT or ANSI Flange as required.
8. Acceptable Manufacturers: Drexelbrook, Endress & Hauser.

B. Hydrostatic Pressure
1. Two wire smart d/p cell type transmitter
2. 4-20 mA or 1 to 5 volt user selectable linear or square root output
3. Adjustable span and zero
4. Stainless steel wetted parts
5. Environmental limits: –40 to 250 °F (-40 to 121°C), 0 to 100% RH
6. Accuracy: less than 0.1 percent of span
7. Output Damping: time constant user selectable from 0 to 36 seconds
8. Vibration Effect: Less than ±0.1% of upper range limit from 15 to 2000 Hz in any axis relative to pipe mounted process conditions.
9. Electrical Enclosure: NEMA 4, 4X, 7, 9
10. Approvals: FM, CSA
11. Acceptable Manufacturers: Rosemount Inc. 3051 Series, Foxboro, and Johnson-Yokagawa.

2.18 INSERTION TYPE TURBINE METER FOR WATER SERVICE

2.19 VORTEX SHEDDING FLOW METER FOR GAS SERVICE:

A. Output: Pulse output, field selectable pulse per units selected

B. Maximum Fluid Temperature: 800 °F

C. Wetted Parts: Stainless Steel

D. Housing: NEMA 4X

E. Turndown: 10:1 minimum.

F. Accuracy: 0.5% of calibrated span for liquids, 1% of calibrated span for gases.

G. Body: Wafer style or ANSI flanged to match piping specification.

H. Acceptable Manufacturers: Foxboro 83 series, Johnson-Yokagawa, and Rosemount.

BUILDING AUTOMATION SYSTEM (BAS) - BASIC MATERIALS,
INTERFACE DEVICES, AND SENSORS

2.20 VENTURI FLOW METER FOR WATER SERVICE

A. Flow Sensing Element: Differential-pressure Venturi-type designed for installation in piping.

B. Construction: Bronze or cadmium plated steel with brass quick connect fittings and attached tag with flow conversion data and rated flow. Ends shall be threaded for 2" and smaller and flanged or welded for larger than 2".

C. Accuracy: Differential transmitter shall be dual range industrial grade as specified above.
   1. Under the reference conditions of a 68 °F media temperature, a 68 °F ambient temperature, a +/- 1% nominal power supply voltage, 10 diameters up stream and 5 down of straight piping and a fully developed flow profile; the meter must meet the following requirements:
   2. +/- 0.8% of reading accuracy in the flow range of 1.65 - 33 ft/sec +/- (0.66/Velocity actual ft/s +0.4)% of reading accuracy in the flow range of 0-1.65 ft/sec.
   3. Meter repeatability shall be +/- 0.1% of rate at velocities > 1.65 ft/sec.

D. Connect differential pressure to venturi and repipe quick connect fittings for measurement. Provide ball valves to isolate quick connects and differential pressure transmitter.

E. Apply Venturi-type flow meters where minimum flow range is no less than 40% of maximum flow.

2.21 AIRFLOW MEASURING STATIONS (AFMS)

A. General Requirements
   1. Sensor Accuracy: ±1.5%
   2. Electronics Accuracy: ±0.5%
   3. Range: Select minimum range to accommodate the expected flow range of the project
   4. Temperature Limits: 20-140°F
   5. Velocity Range: 750 to 9000 fpm
   6. Operating Range: Select minimum range to accommodate the expected flow range of the project

B. Pitot Tube Grids: Provide an array of velocity pressure sensing elements with averaging manifolds and air straightening vanes packaged in a sheet metal casing. Distribute sensing elements in accordance with ASHRAE for traversing ducts. Provide taps to connect tubing from instrumentation. Label AFM with drawing number designation, design flow, velocity pressure, and pressure drop. Application of pitot grids shall be allowed only where minimum expected flow is greater than 30% of maximum flow and greater than manufacturer's minimum flow to achieve accuracy.
   1. Acceptable Manufacturer:
      a. Tek-Air TFP-5000
      b. Kele KMS-DS flow station

C. Hot Wire Grid: Provide an array of hot wire anemometer with air straightening package in a sheet metal casing. Provide averaging circuitry and transmitter to transmit a linear signal proportional to airflow.
   1. Acceptable Manufacturer:
      a. Ebtron
      b. Dybek
      c. Kurtz

D. Vortex Shedding Grid: Provide an array of vortex shedding elements designed to produce stable 'Karmen Vortices' that are linear with air velocity. Provide the electronics to totalize the pulses and output average velocity proportional to an output signal of 4-20ma.
   1. Acceptable Manufacturer: Tek-Air Systems Inc. 'Vortek' Model.

E. Fan Inlet: Provide multi-sensor probes which are installed in the inlet of the fan. Individual sensors on the probe provide direct proportional and linear signals to airflow velocity.

1. Acceptable Manufacturer: Tek-Air Systems Inc. 'Vortek' Model 7000, 8000, or Approved Equal.

2.22 AIR VELOCITY PRESSURE SENSORS (INSERTION TYPE)

A. Single or Multi-Point Averaging (as indicated): Sensing tip shall be for insertion into duct with mounting flange and push on tube connections. Material shall be suitable to the application.

2.23 CO_2 SENSORS/TRANSMITTERS (CARBON DIOXIDE)

A. CO_2 sensors shall use silicon based, diffusion aspirated, infrared single beam, dual-wavelength sensor.

B. Range: 0-2000 ppm

C. Accuracy: ±36ppm at 800 ppm and 68°F.

D. Stability: 5% over 5 years.

E. Output: 4-20 mA, 0-10 Vdc or relay.

F. Mounting: Duct as indicated

G. Acceptable Manufacturer: Vaisala, Inc. GMD20 (duct) or GMW20 (wall), MSA, Inc, Kele 8000 series.

2.24 CO SENSORS/TRANSMITTERS (CARBON MONOXIDE)

A. CO sensors shall use electrochemical sensor.

B. Accuracy: 3% at 0-250 ppm

C. Display & Horn: Progressive or digital display and audible alarm, 65dBA @ 3'.

D. Output: 4-20 mA, 0-10 Vdc .

E. Mounting: Wall mounted between 3' and 5' above the floor in the boiler room.

F. Acceptable Manufacturer: Kele GMT-CO-S1A, MSA, Inc.

2.25 ELECTRIC CONTROL COMPONENTS

A. Limit Switches (LS): Limit switches shall be UL listed, SPDT or DPDT type, with adjustable trim arm. Limit switches shall be as manufactured by Square D, Allen Bradley.

B. Low Temperature Detector ('Freezestat') (FZ): Low temperature detector shall consist of a 'cold spot' element which responds only to the lowest temperature along any one foot of entire element, minimum bulb size of 1/8" x 20', junction box for wiring connections and gasket to prevent air leakage or vibration noise, DPST (4 wire, 2 circuit) with manual reset. Temperature range 15 to 55°F, factory set at 38°F.

C. High Temperature Detectors ('Firestat') (FS): High temperature detector shall consist of 3-pole contacts, a single point sensor, junction box for wiring connections and gasket to prevent air leakage of vibration noise, triple-pole, with manual reset. Temperature range 25 to 215°F.

D. Surface-Mounted Thermostat: Surface-mounted thermostat shall consist of SPDT contacts, operating temperature range of 50 to 150°F , and a minimum 10°F fixed setpoint differential.

E. Low Voltage Wall Thermostat: Wall-mounted thermostat shall consist of SPDT sealed mercury contacts, operating temperature range of 50 to 90°F , switch rating of 24 Vac (30 Vac max.), and both manual and automatic fan operation in both the heat and cool modes.

F. Control Relays: All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA-1 enclosure for indoor locations, NEMA-4 for outdoor locations.
   1. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
      a. AC coil pull-in voltage range of +10%, -15% or nominal voltage.
      b. Coil sealed volt-amperes (VA) not greater than four (4) VA.

c. Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
d. Pilot light indication of power-to-coil and coil retainer clips.
e. Coil rated for 50 and 60 Hz service.
f. Acceptable Manufacturers: Relays shall be Potter Brumfield, Model KRPA.

2. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 HP, and 1/3 HP, shall be rated to break minimum 10 Amps inductive load. Relays shall be IDEC.
3. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.

G. General Purpose Power Contactors: NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA type 1enclosure. Manufacturer shall be Square 'D', Cutler-Hammer or Westinghouse.

H. Control Transformers: Furnish and install control transformers as required. Control transformers shall be machine tool type, and shall be US and CSA listed. Primary and secondary sides shall be fused in accordance with the NEC. Transformer shall be proper size for application, and mounted in minimum NEMA-1 enclosure.
1. Transformers shall be manufactured by Westinghouse, Square ‘D’, or Jefferson.

I. Time Delay Relays (TDR): TDRs shall be capable of on or off delayed functions, with adjustable timing periods, and cycle timing light. Contacts shall be rated for the application with a minimum of two (2) sets of Form C contacts, enclosed in a dustproof enclosure.
1. TDRs shall have silver cadmium contacts with a minimum life span rating of one million operations. TDRs shall have solid state, plug-in type coils with transient suppression devices.
2. TDRs shall be UL and CSA listed, Crouzet type.

J. Electric Push Button Switch: Switch shall be momentary contact, oil tight, push button, with number of N.O. and/or N.C. contacts as required. Contacts shall be snap-action type, and rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen Bradley.

K. Pilot Light: Panel-mounted pilot light shall be NEMA ICS 2 oil tight, transformer type, with screw terminals, push-to-test unit, LED type, rated for 120 VAC. Unit shall be 800T type, as manufactured by Allen-Bradley.

L. Alarm Horn: Panel-mounted audible alarm horn shall be continuous tone, 120 Vac Sonalert solid-state electronic signal, as manufactured by Mallory.

M. Electric Selector Switch (SS): Switch shall be maintained contact, NEMA ICS 2, oil-tight selector switch with contact arrangement, as required. Contacts shall be rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen-Bradley.

2.26 Duct Smoke Detector

A. Photoelectric detector with sampling tube that spans the entire width of duct. .

B. Velocity Rating : 100 to 4000 fpm or 500 to 4000fpm depending on the minimum velocity in the duct. Provide the 100 to 4000 fpm detector if the min duct velocity is below 550 fpm.

C. Output Contact: . Alarm, two sets form “C” rated at 10amps 115V resistive. One set of alarm contacts for BAS monitoring and fan shutdown. Trouble, one set of contacts.

D. Temperature & RH limits: 32 to 120°F and 10 to 85% relative humidity.

E. Acceptable Manufacturer:
1. Invensys FIREX model 2650
2. Sensor Systems DH100ACDCLP
3. Air Products and Controls SL-2000

BUILDING AUTOMATION SYSTEM (BAS) - BASIC MATERIALS,
INTERFACE DEVICES, AND SENSORS

2.27 Electrical Submetering

A. The submetering device will monitor current and voltage on all three phases and provide a pulse output.

B. Accuracy: ±1% from 7% to 100% of rated current (temperature range 0-60C)

C. Transducer: Conform to ANSI C12.1 metering accuracy standards.

D. Output: Pulse with field selectable pulse per kWh.

E. Mounting: In panel or as indicated on the drawing

F. Acceptable Manufacturer: Veris. H8053 for 3 phase loads and Veris H8051 for 1 phase loads.

2.28 NAMEPLATES

A. Provide engraved phenolic or micarta nameplates for all equipment, components, and field devices furnished. Nameplates shall be 1/8 thick, black, with white center core, and shall be minimum 1" x 3", with minimum 1/4" high block lettering. Nameplates for devices smaller than 1" x 3" shall be attached to adjacent surface.

B. Each nameplate shall identify the function for each device.

2.29 TESTING EQUIPMENT

A. Contractor shall test and calibrate all signaling circuits of all field devices to ascertain that required digital and accurate analog signals are transmitted, received, and displayed at system operator terminals, and make all repairs and recalibrations required to complete test. Contractor shall be responsible for test equipment required to perform these tests and calibrations. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range).

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Contractor.

3.2 INSTALLATION OF CONTROL SYSTEMS

A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings. Install electrical components and use electrical products complying with requirements of National Electric Code and all local codes.

B. Main Control Air Piping: All main air piping between the compressors and the control panels shall be copper, run per ASTM B88

C. Branch Control Air Piping: Accessible tubing is defined as that tubing run in mechanical equipment rooms; inside mechanical equipment enclosures, such as heating and cooling units, instrument panels; across roofs, in pipe chases, etc. Inaccessible tubing is defined as that tubing run in concrete slabs; furred walls; or ceilings with no access.

1. Provide copper tubing with maximum unsupported length of 3'-0", for accessible tubing run exposed to view. Polyethylene tubing may be used in lieu of above, when run within adequately supported, rigid enclosure, such as metallic raceways, or EMT. Terminal single-line connections less than 18 in length may be copper tubing, or polyethylene tubing run inside flexible steel protection. Accessible tubing run in concealed locations, such as pipe chases, suspended ceilings with easy access, etc. may be copper or polyethylene bundled and sheathed tubing.
2. Provide copper or polyethylene tubing for inaccessible tubing, other than in concrete pour. If polyethylene tubing is used, install in EMT or vinyl-jacketed polyethylene tubing.

3. Polyethylene piping may be used above suspended ceiling without conduit provided it is run in a neat and orderly fashion, bundled where applicable, and completely suspended (strapped to rigid elements or routed through wiring rings) away from areas of normal access. Tubing shall not be laid on the ceiling or duct.
4. Pressure test control air piping at 30 psi (207 kPa) for 24 hours. Test fails if more than 2 psi loss occurs.
5. Fasten flexible connections bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support tubing neatly.
6. Number-code or color-code tubing, except local individual room control tubing, for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.

D. Control Wiring: The term "control wiring" is defined to include providing of wire, conduit and miscellaneous materials as required for mounting and connection of electric control devices.
1. Wiring System: Install complete wiring system for electric control systems. Install all control wiring external to panels in electric metallic tubing or raceway. On Renovation projects, wiring in finished areas shall be routed in wire mold. The routing of wiring in finished areas must be specifically approved by the AOR/EOR. Installation of wiring shall generally follow building lines. Install in accordance with National Electrical Code and Division 26 of this Specification. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.
2. Control Wiring Conductors: Install control wiring conductors, without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code and Division 26 of this Specification.
3. Communication wiring, signal wiring and low voltage control wiring shall be installed separate from any wiring over thirty (30) volts. Signal wiring shield shall be grounded at controller end only, unless otherwise recommended by the controller manufacturer.
4. All WAN and LAN Communication wiring shield shall be terminated as recommended by controller manufacturer. All WAN and LAN Communication wiring shall be labeled with a network number, device ID at each termination and shall correspond with the WAN and LAN system architecture and floor plan submittals. All WAN and LAN cabling shall comply with applicable Division 26 requirements.
5. Number-code or color-code conductors appropriately for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.

E. Control Valves: Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, install with valve stem axis vertical, with operator side up. Where vertical stem position is not possible, or would result in poor access, valves may be installed with stem horizontal. Do not install valves with stem below horizontal, or down.

F. Freezestats: Install freezestats in a serpentine fashion where shown on drawing. Provide one foot of element for each square foot of coil face area. The length of element not just down stream of the coil will not be included in the coverage calculation. Where coil face area exceeds required length of element, provide multiple devices, wired in parallel for normally open close on trip application, wired in series for normally closed, open on trip application. Adequately support with coil clips such that sensor is not in direct contact with equipment. Coordinate the location of the switch such that it is normally accessible.

G. Room Temperature Sensors: Install sensors as shown on the drawings. Provide approved security screws for mounting, matching those installed in other areas of the project. Provide 3 tools to the Owner for installation and removal of the security screws. Seal conduit penetrations at the wall box airtight. Install batt insulation in the wall box to completely fill the box. Electrical connections shall be made using a twist-on sealant filled connectors suitable for the installation.

BUILDING AUTOMATION SYSTEM (BAS) - BASIC MATERIALS,
INTERFACE DEVICES, AND SENSORS

H. Averaging Temperature Sensors: Cover no more than three square feet per linear foot of sensor length except where indicated. Generally the sensor will be located where flow is sufficiently homogeneous/adequately mixed , consult AE for requirements.

I. Airflow Measuring Stations: Install per manufacturer's recommendations in an unobstructed straight length of duct (except those installations specifically designed for installation in fan inlet). For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFM station manufacturer.

J. Fluid Flow Sensors: Install per manufacturer's recommendations in an unobstructed straight length of pipe.

K. Relative Humidity Sensors: Provide element guard as recommended by manufacturer for high velocity installations. For high limit sensors, position remote enough to allow full moisture absorption into the air stream before reaching the sensor.

L. Differential Pressure Transmitters: Provide valve bypass arrangement to protect against over pressure damaging the transmitter.

M. Flow Switches: Where possible, install in a straight run of pipe at least 15 diameters in length to minimize false indications.

N. Current Switches for Motor Status Monitoring: Adjust so that setpoint is below minimum operating current and above motor no load current.

O. Supply Duct Pressure Transmitters:
   1. General: Install pressure tips with at least 4 'round equivalent' duct diameters of straight duct with no takeoffs upstream. Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer's installation instructions. Locate the transmitter at an accessible location to facilitate calibration.
   2. VAV System 'Down-Duct' Transmitters: Locate pressure tips approximately 2/3 of the hydraulic distance to the most remote terminal in the air system.

P. Cutting and Patching Insulation: Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.

END OF SECTION

BUILDING AUTOMATION SYSTEM (BAS) - OPERATOR INTERFACES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:
   1. Site Control System Server (CSS)/ Operator Workstation (OWS).
   2. Portable Operator Terminal (POT).
   3. Printers.

1.2 DESCRIPTION OF WORK

A. Furnish and install all Operator Interfaces and Control System Servers as required for the BAS functions specified. All computers shall be warranted by the manufacturer for a period of one year after final acceptance. The Owner's strategic supplier of Microsoft based computers is Dell so all OWS and POT computers will be Dell. CSS computers will also be Dell unless the BAS system manufacturer manufactures the computer.

B. All computers shall meet the requirements of the Owner as published in the "Minimum Hardware, Software, and Network Standards".

C. Refer to Division 23 Section "Building Automation System (BAS)," for general requirements.

PART 2 - PRODUCTS

2.1 SITE WEB SERVER, CONTROL SYSTEM SERVER (CSS)

A. The CSS web server shall support browser access via Microsoft Internet Explorer 5.0 (or higher), or Navigator Netscape 6.0 (or higher).

B. The server will have two, (2), LAN network cards compatible with the Owner's WAN and BAS LAN systems or as shown on the BAS control riser diagram. The server computer will not function as the workstation. The web server will provide the link between the Owner's WAN and BAS LAN.

C. All information exchanged over Internet shall be optionally encrypted and secure via SSL.

D. E-mail – The system will be able to generate e-mails automatically for alarming using a "MS – Outlook" or similar platform that meets the requirements of the Owner's as published in the "Minimum Hardware, Software, and Network Standards".

E. The web server licensing options will allow concurrent access by an unlimited number of browser connections.

F. Provide software registration cards to the Owner for all included software.

G. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™ or Netscape Navigator™. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable. For example, a webserver that requires a Java script to load would not be acceptable nor would the use of an alternate to a webserver such as Microsoft Terminal Services.

H. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the FMS, shall not be acceptable.

I. The Web server shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

J. Provide all software, cables, peripherals etc. for a complete system.

K. Provide network configuration tool, all programming applications, graphic creation tools and all other software required to configure and operate the system.

L. For CSSs that provide web services for presentation of data across the Internet, all Web components and services shall be installed with required licensing. CSS shall be configured to secure it to the extent practical inside the Local Supervisory LAN. CSS shall always function from behind a firewall provided either by the Owner's network administrators in the case where they provide the LAN infrastructure, or by this contractor where the LAN is provided under this Division of the specifications.

M. Provide network card approved by BAS manufacturer to support Supervisory LAN communications (100 Mbps Ethernet TCP/IP)

N. Control System Server shall be placed as indicated on the drawings or as directed by the Owner.

O. The CSS will meet or exceed the requirements for the OWS hardware.

2.2 OPERATOR WORKSTATION (OWS)

A. The computer hardware will meet the Owner's requirements as published in the "Minimum Hardware, Software, and Network Standards".

B. Provide software registration cards to the Owner for all included software.

C. Provide (as a minimum) a personal computer (PC) with Intel Pentium 4 processor operating at 3.0GHz minimum speed. Include 2 GB RAM and minimum of two (2) 160GB, 7,200 RPM hard disk drives. These drives will operate as a set of mirrored RAID 1 hard drives with the associated software and/or hardware provided. These drives and the associated controllers supplied and warranted by Dell. Provide a 128 MB graphics card, four USB ports, 10/100 Base-T network card, 48x/24x/48x\16x CD-RW/DVD ROM Combo Drive.

D. Provide 17 in flat panel Monitor.

E. Provide detachable keyboard with standard typewriter layout, function keys, and separate numeric keypad. Provide an optical mouse and mouse pad with the system. Provide one open serial port after configuration of the workstation to meet the requirements of the rest of these specifications.

F. Workstation PC shall have the capability of changing serial port interrupt vectors and IOBASE addresses through software.

G. Provide an uninterruptible power supply system providing battery backup for the operator workstation and peripheral devices, excluding the printer.. UPS shall protect against blackouts, brownouts, surges and noise. UPS shall include LAN port and modem line surge protection. UPS shall be sized for a 4-minute full load runtime, 12-minute ½ load runtime, with a typical runtime of up to 30 minutes. Transfer time shall be 2-4 milliseconds. UPS shall provide a 480-joule suppression rating and current suppression protection for 36,000 amps and provide 90% recharge capability in 2-4 hours. Suppression response time shall be instantaneous. UPS low voltage switching shall occur when supply voltage is less than 94 volts. UPS shall be provided with phone and data surge suppression and LAN port connections. Provide all software, cables, peripherals etc. for a complete system including software to automatically shutdown the computer .

H. Operating system for operator workstation shall be Microsoft Windows 7 or 8. Provide Microsoft Office current professional software. All software shall be at least the latest version available as of the date of contract completion.

I. Provide network configuration tool, all programming applications, graphic creation tools and all other software required to configure and operate the system.

J. Provide network card approved by BAS manufacturer to support Supervisory LAN communications (100 Mbps Ethernet TCP/IP)

BUILDING AUTOMATION SYSTEM (BAS) - OPERATOR INTERFACES

K. Provide additional hardware, video drivers, etc., to facilitate all control functions and software requirements specified for the BAS.

L. OWS shall be placed as indicated on the drawings or as directed by the Owner.

2.3 PORTABLE OPERATORS TERMINAL (POT) / REMOTE WORKSTATION

A. Portable Operators Terminal shall support system management by connection to the controllers, by connection via the Internet, and by dial-up communications while serving as the remote workstation. The computer will be a Dell computer.

B. Provide (as a minimum) one notebook personal computer (PC) with Intel 4 processor, 2.66GHz, 14.1 XGA display, Include 1GB RAM and one 60GB/7200 RPM hard disk drive. Provide 32 MB graphics card, , Two USB ports, 10/100 Base-T network card and 24X/24X/24X/8X CD-RW/DVD ROM Combo Drive.

C. Provide a 10/100 LAN+56K CardBus Type III PC Card

D. Provide minimum 14.1" XGA active matrix display.

E. Provide carrying case and extra battery.

F. Operating system for operator workstation shall be Microsoft Windows 2000 Professional. Provide Microsoft Office 2000 Professional or Office XP Professional Software.

G. Provide software, graphics and programming as specified in Division 23 Section “BAS Software and Programming“.

H. Provide additional hardware, video drivers, serial ports, etc., to facilitate all control functions and software requirements specified for the building automation system.

I. Provide all controller configuration and interface software and/or plug ins for all devices applicable. All shall be loaded and functional. Provide all required interface cables required to connect to all networks, routers, controllers, SDs etc.

2.4 PRINTERs

A. Provide the Following Printer: 1200x1200 dpi, min 15pages per minute color, 21 pages per minute black. 8-1/2” x 11” paper tray. HP Deskjet 5650 or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set up the workstations and printers as indicated. Install all software and verify that the systems are fully operational. Ensure licensing is provided for all software.

B. No license, software component, key, etc or any piece of information required to install, configure, operate, diagnose and maintain the system shall be withheld from the Owner.

C. Install electronic control system Operation and Maintenance Manuals, programming guides, network configuration tools, control shop drawings etc on each OWS and CSS. Provide interface or shortcuts to guide user to the appropriate information.

D. Set up portable operator terminal and configure it as the remote workstation. Install all software and verify that the system is fully operational.

E. Install systems and materials in accordance with manufacturer’s instructions.

END OF SECTION

BUILDING AUTOMATION SYSTEM (BAS) - FIELD PANELS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:
   1. Building Controllers (BC).
   2. Application Specific Controllers (ASC).
   3. Advanced Application Controllers (AAC).

1.2 DESCRIPTION OF WORK

A. Furnish and install DDC Control units and/or Smart Devices required to support specified building automation system functions.

B. Refer to Division 23 Section “Building Automation System (BAS)” for general requirements.

PART 2 - PRODUCTS

2.1 Spare points

A. Provide field panels and controllers with a minimum of 10% capacity of spare points expandability for AI/AO/DI/DO.

2.2 Stand-Alone Functionality

A. General: These requirements clarify the requirement for stand-alone functionality relative to packaging I/O devices with a controller. Stand-alone functionality is specified with the controller and for each Application Category specified in PART 3. This item refers to acceptable paradigms for associating the points with the processor.

B. Functional Boundary: Provide controllers so that all points associated with and common to one unit or other complete system/equipment shall reside within a single control unit. The boundaries of a standalone system shall be as dictated in the contract documents. Generally systems specified for the Application Category will dictate the boundary of the standalone control functionality. See related restrictions below. When referring to the controller as pertains to the standalone functionality, reference is specifically made to the processor. One processor shall execute all the related I/O control logic via one operating system that uses a common programming and configuration tool.

C. The following configurations are considered acceptable with reference to a controller’s standalone functionality:
   1. Points packaged as integral to the controller such that the point configuration is listed as an essential piece of information for ordering the controller (having a unique ordering number).
   2. Controllers with processors and modular back planes that allow plug in point modules as an integral part of the controller.
   3. I/O point expander boards, plugged directly into the main controller board to expand the point capacity of the controller.
   4. I/O point expansion devices connected to the main controller board via wiring and as such shall be remote from the controller and that communicate via a sub LAN protocol. These arrangements to be considered standalone shall have a sub LAN that is dedicated to that controller and include no other controller devices. All wiring to interconnect the I/O expander board shall be:
      a. Contained in the control panel enclosure;
      b. Or run in conduit. Wiring shall only be accessible at the terminations.
   5. General purpose LonMark I/O devices or Smart Devices racked with a processor module in the same contiguous physical enclosure. The controller shall also include its own dedicated processor module and bridge or router making the controllers LAN communication a subnet or LAN segment dedicated to that controller as specified under Application Categories below. The following are additional requirements of this configuration:
      a. Configuration must meet the requirements for battery back up.
      b. If processor fails, the I/O devices shall go to their fail condition.

c. Contractor shall provide a network bandwidth analysis of the controller segment or subnet. The analysis shall document network bandwidth utilization does not exceed 30% for a continuous one hour period.
d. Logic must provide for orderly sequencing of I/O during a power interruption and restart of program logic upon restoration of power.
e. Programming must facilitate a robust uploading scheme using LONMark File Transfer Protocol and limit available bandwidth during upload.
f. Trending shallshall be buffered in the processor or dedicated data logging module and uploaded to the Tridium JACE, or buffered in the Tridium JACE.

2.3 Building Controller (BC)

A. General Requirements:

1. The BC(s) shall provide fully distributed control independent of the operational status of the OWSs and CSS. All necessary calculations required to achieve control shall be executed within the BC independent of any other device. All control strategies performed by the BC(s) shall be both operator definable and modifiable through the Operator Interfaces.
2. BCs shall perform overall system coordination, accept control programs, perform automated HVAC functions, control peripheral devices and perform all necessary mathematical and logical functions. BCs shall share information with the entire network of BCs and AACs/ASCs for full global control. Each controller shall permit multi-user operation from multiple workstations and portable operator terminals connected either locally or over the Primary Controller LAN. Each unit shall have its own internal RAM, non-volatile memory, microprocessor, battery backup, regulated power supply, power conditioning equipment, ports for connection of operating interface devices, and control enclosure. BCs shall be programmable from an operator workstation, portable operator's terminal, or hand held operating device. BC shall contain sufficient memory for all specified global control strategies, user defined reports and trending, communication programs, and central alarming.
3. BCs shall be connected to a controller network that qualifies as a Primary Controlling LAN.
4. All BCs shall be protected from any memory loss due to a loss of power by one or a combination of the following:
   a. Volatile RAM shall have a battery backup using a lithium battery with a rated service life of fifty (50) hours, and a rated shelf life of at least five years. Self-diagnostic routine shall report an alarm for a low battery condition.
   b. EEPROM, EPROM, or NOVROM non-volatile memory
5. In addition BCs shall provide intelligent, standalone control of HVAC functions. Each BC shall be capable of standalone direct digital operation utilizing its own processor, non-volatile memory, input/output, wiring terminal strips, A/D converters, real-time clock/calendar and voltage transient and lightning protection devices. Refer to standalone functionality specified above.
6. The BC shall provide for point mix flexibility and expandability. This requirement shall be met via either a family of expander boards, modular input/output configuration, or a combination thereof. Refer to stand alone functionality specified above.
7. All BC point data, algorithms and application software shall be modifiable from the Operator Workstation.
8. Each BC shall execute application programs, calculations, and commands via a microprocessor resident in the BC. The database and all application programs for each BC shall be stored in non-volatile or battery backed volatile memory within the BC and will be able to upload/download to/from the OWS and/or CSS.
9. BC shall provide buffer for holding alarms, messages, trends etc.
10. Each BC shall include self-test diagnostics, which allow the BC to automatically alarm any malfunctions, or alarm conditions that exceed desired parameters as determined by programming input.
11. Each BC shall contain software to perform full DDC/PID control loops.

12. For systems requiring end-of-line resistors those resistors shall be located in the BC, if it has I/O capability.
13. Input-Output Processing
    a. Digital Outputs (DO): Outputs shall be rated for a minimum 24 Vac or Vdc, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output and Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
    b. Analog Inputs (AI): AI shall be O-5 Vdc, 0-10 Vdc, 0-20 Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 12 bits.
    c. Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board. Software multiplexing of an AI and resistors shall only be done in non-critical applications and only with prior approval of Architect/Engineer.
    d. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
    e. Electronic Analog Outputs (AO): Voltage mode: 0-5 Vdc and 0-10 Vdc; Current mode: 4-20 mA. Provide zero and span calibration and circuit protection. Pulse Width Modulated (PWM) analog via a DO and transducer is acceptable only with the Owner's approval (PWM will not be allowed on loops with a short time constant such as discharge temperature loops, economizer loops, pressure control loops and the like. They are generally acceptable for standard room temperature control loops). Where these are allowed, transducer/actuator shall be programmable for normally open, normally closed, or hold last position and shall allow adjustable timing. PWM controlled devices will have an automatically initiated function that resets the device position tracking on a scheduled basis. The controllers shall initially be set up to perform this function once every 24 hours. The purpose of this required function is to recalibrate the position tracking to assure the device will open and close completely when commanded. Each AO shall be discrete outputs from the PCU's board (multiplexing to a separate manufacturers board is unacceptable). D/A converters shall have a minimum resolution of 10 bits.
    f. Analog Output Pneumatic (AOP), 0-20 psi: Pneumatic outputs via an I/P transducer, or digital to pneumatic transducer are acceptable. Multiplexed digital to pneumatic transducers are acceptable provided they are supplied as a standard product and part of the BC and provide individual feedback. Multiplexed pneumatic outputs of a separate manufacturer are unacceptable.
    g. Pulsed Inputs: Capable of counting up to 8 pulses per second with buffer to accumulate pulse count. Pulses shall be counted at all times.
14. A communication port for operator interface through a terminal shall be provided in each BC. It shall be possible to perform all program and database back-up, system monitoring, control functions, and BC diagnostics through this port. Standalone BC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or workstations.
15. Each BC shall be equipped with loop tuning algorithm for precise proportional, integral, derivative (PID) control. Loop tuning tools provided with the Operator Workstation software is acceptable. In any case, tools to support loop tuning must be provided such that P, I, and D gains are automatically calculated.
16. Slope intercepts and gain adjustments shall be available on a per-point basis.
17. BC Power Loss:
    a. Upon a loss of power to any BC, the other units on the primary controlling network shall not in any way be affected.

b. Upon a loss of power to any BC, the battery backup shall ensure that the energy management control software, the Direct Digital Control software, the database parameters, and all other programs and data stored in the RAM are retained for a minimum of fifty (50) hours.
c. Upon restoration of power within the specified battery backup period, the BC shall resume full operation without operator intervention. The BC shall automatically reset its clock such that proper operation of any time dependent function is possible without manual reset of the clock. All monitored functions shall be updated.
d. Should the duration of a loss of power exceed the specified battery back-up period or BC panel memory be lost for any reason, the panel shall automatically report the condition (upon resumption of power) and be capable of receiving a download via the network, and connected computer. In addition, the owner shall be able to upload the most current versions of all energy management control programs, Direct Digital Control programs, database parameters, and all other data and programs in the memory of each BC to the operator workstation via the local area network, or via the telephone line dial-up modem where applicable, or to the laptop PC via the local RS-232C port.

18. BC Failure:
a. Building Controller LAN Data Transmission Failure: BC shall continue to operate in stand-alone mode. BC shall store loss of communication alarm along with the time of the event. All control functions shall continue with the global values programmable to either last value or a specified value. Peer BCs shall recognize the loss, report alarm and reconfigure the LAN.
b. BC Hardware Failure: BC shall cease operation and terminate communication with other devices.
19. Each BC shall be equipped with firmware resident self-diagnostics for sensors and be capable of assessing an open or shorted sensor circuit and taking an appropriate control action (close valve, damper, etc.).
20. BCs shall include LAN communications interface functions for controlling secondary controlling LANs Refer to Division 23 Section " Building Automation System (BAS) - Communications Devices" for requirements if this function is packaged with the BC.
21. A minimum of four levels of password protection shall be provided at each BC.
22. BCs shall be mounted on equipment, in packaged equipment enclosures, or locking wall mounted in a NEMA 1 enclosure.

B. BACnet Building Controller Requirements:
1. The BC(s) shall support all BIBBs defined in the BACnet Building Controller (B-BC) device profile as defined in the BACnet standard.
2. BCs shall communicate over the BACnet Building Controller LAN.
3. Each BC shall be connected to the BACnet Building Controller LAN communicating to/from other BCs.

C. LonTalk Building Controller Requirements:
1. All products shall be LonMark certified, and shall be designed according to the LonMark Interoperability Guidelines. Product documentation and devices shall display the LonMark symbol, indicating conformance to the LonMark Interoperability Standards.
a. In those instances in which LonMark devices are not available, the Network Integrator shall provide LonWorks devices with application source code, device resource files, and external interface definitions. The software tools required to install and commission the device shall be provided for non-LonMark devices.
2. All products shall support and be certified to an appropriate LonMark functional profile. Where published profiles do not exist, use draft profile standards or submit a proposed draft as part of the submittal package. All drafts shall also be submitted simultaneously to the LonMark Interoperability Association for certification.
3. An external interface file (*.XIF) shall be provided for each LonTalk device describing network variables, configuration parameters and other parameters supported.

4. All products shall utilize standard configuration parameter types for all product configuration parameters. Do not use network variables for this purpose.
5. The use of manufacturer-defined network variables and configuration parameters shall be limited to factory-configured parameters. All data and configuration parameters that shall be required for field installation, service and maintenance shall be represented using standard LonMark network variables and configuration parameters. Modification of LonMark certified network variables and configuration parameters is unacceptable.
6. Provide LonTalk bridge or routers and repeaters as required to combine different secondary (TP/FT-10) networks onto the primary Ethernet/IP network, or as required to segment groups of LonTalk devices to meet minimum throughput requirements.
7. Provide all necessary bridge or routers and gateways in order to connect TP/FT-10 devices to the primary network, and to connect the primary network to the GEMnet.
8. The network services for the BAS shall be the latest version of LonWorks Network Services (LNS).
9. Device to device communication shall be event driven and peer to peer.
10. Propagation of data from a PCU to a Router for the execution of supervisory control logic shall be event driven at the device and not based on polling from the Router.
11. Propagation of data from a PCU to a Router to support non-alarm dynamic data display or for trending purposes shall be based on polling from the Router.
12. Propagation of data from a PCU to a Router to support the reporting of alarm conditions shall be event driven at the device and not based on polling from the Router.
13. The programming of all output network variables shall include the send on delta concept; minimum send time and maximum send time parameters.
    a. Send on delta parameters shall be non-zero values selected to ensure efficient use of the available bandwidth but not exceeding the following:
        1) Temperatures: 0.36 Degrees Fahrenheit
        2) Pressures In Air Systems: 0.025 Inches Of Water
        3) Building Static Pressure: 0.0125 Inches Of Water
        4) Flow: Approximately 10 Cfm or 2% of the system operating range
        5) Relative Humidity: 3%
        6) Analog Position: 2%
        7) Enthalpy: Approximately 0.2 Btu Per Lb
        8) Binary Alarm Data: Change of State
    b. If the minimum send time parameters can be set on a point by point basis, they shall not exceed the following:
        1) Alarms: 1 second
        2) Temperatures at Zone Level: 60 seconds
        3) Temperatures at Central Station Level: 10 seconds for data reporting, 5 seconds for control purposes
        4) Pressures: 5 seconds for data reporting, 1 second for control purposes.
    c. If the minimum send time parameters can only be set on a controller basis, set the parameter at a value of 5 seconds.
14. The error rate for each channel shall be verified by a one hour test using the network analysis tool. The error rate shall not exceed 1%.
15. The bandwidth utilization for each channel shall be verified by a one hour test using the network analysis tool. The utilization shall not exceed 30%.
16. All products shall be LonMark certified, and shall be designed according to the LonMark Interoperability Guidelines. Product documentation and devices shall display the LonMark symbol, indicating conformance to the LonMark Interoperability Standards.
    a. In those instances in which LonMark devices are not available, the Network Integrator shall provide LonWorks devices with application source code, device resource files, and external interface definitions. The software tools required to install and commission the device shall be provided for non-LonMark devices.
17. All products shall support and be certified to an appropriate LonMark functional profile. Where published profiles do not exist, use draft profile standards or submit a proposed

draft as part of the submittal package. All drafts shall also be submitted simultaneously to the LonMark Interoperability Association for certification.

18. An external interface file (*.XIF) shall be provided for each LonTalk device describing network variables, configuration parameters and other parameters supported.
19. All products shall utilize standard configuration parameter types for all product configuration parameters. Do not use network variables for this purpose.
20. The use of manufacturer-defined network variables and configuration parameters shall be limited to factory-configured parameters. All data and configuration parameters that shall be required for field installation, service and maintenance shall be represented using standard LonMark network variables and configuration parameters. Modification of LonMark certified network variables and configuration parameters is unacceptable.
21. Provide LonTalk bridge or routers and repeaters as required to combine different secondary (TP/FT-10) networks onto the primary Ethernet/IP network, or as required to segment groups of LonTalk devices to meet minimum throughput requirements.
22. Provide all necessary bridge or routers and gateways in order to connect TP/FT-10 devices to the primary network, and to connect the primary network to the GEMnet WAN.
23. The network services for the BAS shall be the latest version of LonWorks Network Services (LNS), no exceptions allowed.
24. The Network Management Application shall be LonMaker™ for Windows (Latest Released Version) service tool (including hardware, software and any peripheral devices required) and is to be used for commissioning and management of the LonTalk control architecture, no exceptions allowed. The network management service tool shall remain on the project as the property of GSA. A copy of the LonTalk Network Database Shall Be Archived on the service tool and Site Control System Server (CSS)/ Operator Workstation (OWS), documenting system bindings and node addressing. In addition all system variables shall have a plain English language description for each variable. This service tool shall be used for all system maintenance and expansion, so that the network database backup remains current.

2.4 Advanced Application Specific Controller (AAC) and Application Specific Controller (AsC)

A. General Requirements:

1. AACs and ASCs shall provide intelligent, standalone control of HVAC equipment. Each unit shall have its own internal RAM, non-volatile memory and will continue to operate all local control functions in the event of a loss of communications on the ASC LAN or sub-LAN. Refer to standalone requirements by application specified in PART 3 of this Section. In addition, it shall be able to share information with every other BC and AAC /ASC on the entire network.
2. Each AAC and ASC shall include self-test diagnostics that allow the AAC /ASC to automatically relay to the BC, LAN Interface Device or workstation, any malfunctions or abnormal conditions within the AAC /ASC or alarm conditions of inputs that exceed desired parameters as determined by programming input.
3. AACs and ASCs shall include sufficient memory to perform the specific control functions required for its application and to communicate with other devices.
4. Each AAC and ASC must be capable of stand-alone direct digital operation utilizing its own processor, non-volatile memory, input/output, minimum 8 bit A to D conversion, voltage transient and lightning protection devices. All volatile memory shall have a battery backup of at least fifty- (50) hrs with a battery life of five years.
5. All point data; algorithms and application software within an AAC /ASC shall be modifiable from the Operator Workstation.
6. AAC and ASC Input-Output Processing
   a. Digital Outputs (DO): Outputs shall be rated for a minimum 24 VAC or VDC, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output and Each DO shall be discrete outputs from the AAC/ASC's board (multiplexing to a separate

manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.

b. Analog Inputs (AI): AI shall be 0-5 Vdc, 0-10Vdc, 0-20Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 8-10 bits depending on application.
c. Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board. Software multiplexing of an AI and resistors shall only be done in non-critical applications and only with prior approval of Architect/Engineer
d. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
e. Electronic Analog Outputs (AO): Voltage mode: 0-5 Vdc and 0-10 Vdc; Current mode: 4-20 mA. Provide zero and span calibration and circuit protection. Pulse Width Modulated (PWM) analog via a DO and transducer is acceptable only with the Owner's approval (PWM will not be allowed on loops with a short time constant such as discharge temperature loops, economizer loops, pressure control loops and the like. They are generally acceptable for standard room temperature control loops). Where these are allowed, transducer/actuator shall be programmable for normally open, normally closed, or hold last position and shall allow adjustable timing. PWM controlled devices will have an automatically initiated function that resets the device position tracking on a scheduled basis. The controllers shall initially be set up to perform this function once every 24 hours. The purpose of this required function is to recalibrate the position tracking to assure the device will open and close completely when commanded. Each AO shall be discrete outputs from the PCU's board (multiplexing to a separate manufacturers board is unacceptable). D/A converters shall have a minimum resolution of 10 bits.
f. Analog Output Pneumatic (AOP), 0-20 psi: Pneumatic outputs via an I/P transducer, or digital to pneumatic transducer are acceptable. Multiplexed digital to pneumatic transducers are acceptable provided they are supplied as a standard product and part of the AAC /ASC and provide individual feedback. Multiplexed pneumatic outputs of a separate manufacturer are unacceptable.

B. BACnet AAC(s) and ASC(s) Requirements:
1. The AAC(s) and ASC(s) shall support all BIBBs defined in the BACnet Building Controller (B-AAC and B-ASC) device profile as defined in the BACnet standard.
2. AAC(s) and ASC(s) shall communicate over the BACnet Building Controller LAN or the ASC LAN or sub-LAN.
3. Each BC shall be connected to the BACnet Building Controller LAN communicating to/from other BCs.

C. LonTalk AAC(s) and ASC(s) Requirements:
1. Refer to LonWorks requirements under BC. All apply also to the AACs and ASCs.

D. Terminal Box Controllers:
1. Terminal box controllers controlling damper positions to maintain a quantity of supply or exhaust air serving a space shall have an automatically initiated function that resets the volume regulator damper to the fully closed position on a scheduled basis. The controllers shall initially be set up to perform this function once every 24 hours. The purpose of this required function is to reset and synchronize the actual damper position with the calculated damper position and to assure the damper will completely close when commanded. The software shall select scheduled boxes randomly and shall not allow more than 5% of the total quantity of controllers in a building to perform this function at the same time. When possible the controllers shall perform this function when the supply or exhaust air system is not operating or is unoccupied.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Contractor.

3.2 System Access:

A. Provide an Ethernet connection and 5 port hub at each panel housing a controller or controllers, that provides access to the Local Supervisory LAN and to the Control System Server for all Controllers, other than an Application Category 1 Controllers. The user shall be able to access each controller on the system using this connection via the Control System Server database for graphics, schedules, programming, controller configuration etc.

3.3 INSTALLATION OF CONTROL SYSTEMS:

A. General: Install systems and materials in accordance with manufacturer's instructions, specifications roughing-in drawings and details shown on drawings. Contractor shall install all controllers in accordance with manufacturer's installation procedures and practices.

3.4 HARDWARE APPLICATION REQUIREMENTS

A. Here is where you assert your concept of optimal mix of power/quality/cost effectiveness. There are multiple levels of controller/application defined, the higher Category numbers being more powerful and expensive. The AE defines - within each category - what system(s) must be controlled (in standalone fashion) by controllers that meet that category. This item needs specific attention on every project.

B. General: The functional intent of this specification is to allow cost effective application of manufacturers standard products while maintain the integrity and reliability of the control functions. Specific requirements indicated below are required for the respective application. Manufacturer shall apply the most cost-effective unit that meets the requirement of that application.

C. Standalone Capability: Each Control Unit shall be capable of performing the required sequence of operation for the associated equipment. All physical point data and calculated values required to accomplish the sequence of operation shall originate within the associated CU with only the exceptions enumerated below. Refer to Item 2.01 above for physical limitations of standalone functionality. Listed below are functional point data and calculated values that shall be allowed to be obtained from or stored by other CUs or SDs via LAN.

D. Where associated control functions involve functions from different categories identified below, the requirements for the most restrictive category shall be met.

E. Application Category Type 0 (Distributed monitoring)
   1. Applications in this category include the following:
      a. Monitoring of variables that are not used in a control loop, sequence logic, or safety.
   2. Points on BCs, AACs, and ASCs may be used in these applications as well as Ds and/or general-purpose I/O modules.
   3. Where these points are trended, contractor shall verify and document that the network bandwidth is acceptable for such trends and is still capable of acceptable and timely control function.
   4. LAN Restrictions: These points may reside on any controller

F. Application Category Type 1
   1. Applications in this category include the following:
      a. Fan Coil Units
      b. Airflow Control Boxes (VAV and Constant Volume Terminal Units)
      c. Terminal Control Dampers/Reheat Vales
      d. Unitary equipment <15 tons (Package Terminal AC Units, Package Terminal Heat Pumps, Split-System AC Units, Split-System Heat Pumps, and Water-Source Heat Pumps)

e. Induction Units

2. Standalone Capability: Provide capability to execute control functions for the application for a given setpoint or mode, which shall generally be occupied mode control. Only the following data (as applicable) may be acquired from other controllers via LANs. In the event of a loss of communications with any other controller, or any fault in any system hardware that interrupts the acquisition of any of these values, the ASC shall use the last value obtained before the fault occurred. If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

Physical/Virtual Point	Default Value
Scheduling Period	Normal
Morning Warm-Up	Off (cold discharge air)
Load Shed	Off (no shedding)
Summer/Winter	Winter
Trend Data	N/A

3. Mounting:
   a. ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use.
   b. ASCs that control equipment mounted in a mechanical room shall either be mounted in, on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
   c. ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.
   d. Contractor for this Section may furnish ASCs to the terminal unit manufacturer for factory mounting.
4. LAN Segment Restrictions:
   a. LonTalk systems: Limit the number of nodes servicing any one of these applications on the LAN Segment to 40. VAV terminals or zone dampers/reheat coils served by a single air handler are to be located on the same segment of the LAN with the AHU. Multiple AHU's may reside on a LAN segment if all the associated/served terminal boxes and zone dampers/reheat coils are located on the same LAN segment. If more than 40 VAV terminals or zone dampers/reheat coils are served by a single air handler, then one LAN segment shall be fully populated with the parent air handler and terminal unit Nodes with the balance of the served terminal units Nodes located on the other segment located on the single channel JACE.
   b. BACnet Systems: Limit the number of AAC's/ASC's servicing any one of these applications on the LAN Segment to 32.

G. Application Category Type 2
1. Applications in this category include the following:
   a. Constant Volume Air Handlers
   b. Unitary Equipment >= 15 tons (Air Conditioners, Heat Pumps, Packaged Heating/Cooling Units, and the like)
   c. Constant Volume Pump Start/Stop
   d. Misc. Equipment (Exhaust Fan) Start/Stop
   e. Misc. Monitoring (not directly associated with a control sequence and where trending is not critical)
   f. Variable Speed Drive (VSD) controllers not requiring safety shutdowns of the controlled device
   g. Multizone Air handlers with fewer than 5 zones
2. Standalone Capability: Only the following data (as applicable) may be acquired from other AACs via LANs. In the event of a loss of communications with any other AACs, or any fault in any system hardware that interrupts the acquisition of any of these values, the AAC shall use the last value obtained before the fault occurred. If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

Physical/Virtual Point	Default Delay Time	Default Value
Outside Air Temperature	3 minutes	80°F
Outside Air Humidity	3 minutes	60%RH
Outside Air Enthalpy	3 minutes	30 Btu/lb
Trend Data		N/A
Cooling/Heating Requests	3 minutes	None

3. Mounting:
   a. AACs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use.
   b. AACs that control equipment mounted in a mechanical room may either be mounted in, on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
   c. AACs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.
4. LAN Segment Restrictions:
   a. LonTalk systems: Limit the number of nodes servicing any one of these applications on the LAN Segment to 40.
   b. BACnet Systems: Limit the number of AAC's servicing any one of these applications on the LAN Segment to 32.

H. Application Category Type 3
1. Applications in this category include the following:
   a. VAV Air Handlers
   b. Dual Duct Air Handlers
   c. Multizone Air Handlers with 5 or more zones
   d. Self Contained VAV Units
   e. Central Cooling Plant
   f. Central Heating Plant
   g. Cooling Towers
   h. Sequenced or Variable Speed Pump Control
   i. Local Chiller Control (unit specific)
   j. Local Free Cooling Heat Exchanger Control
2. LAN Segment Restrictions:
   a. LonTalk systems: Limit the number of PCU's servicing any one of these applications on the LAN Segment to 20. Only PCU's associated with equipment for the applications in this category shall reside on the LAN segment of this application category type, with the exception of Application Category Type 0 points.
3. BACnet Systems: BCs shall be used in these applications.

3.5 CONTROL UNIT REQUIREMENTS

A. Refer to Division 23 Section "Building Automation System (BAS)" for requirements pertaining to control unit quantity and location.

END OF SECTION

BUILDING AUTOMATION SYSTEM (BAS) - COMMUNICATION DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes network integration devices.

1.2 DESCRIPTION OF WORK

A. Contractor shall provide all interface devices and software to provide an integrated system connecting Advanced Application Controllers, Application Specific Controllers, Building Controllers, Gateways, and Operator Work Station & Control System Server. The Control System Server will also be connected to the Owner's WAN.

B. Refer to Division 23 Section "Building Automation System (BAS)," for general requirements.

PART 2 - PRODUCTS

2.1 NETWORK CONNECTION

A. The Owner's WAN: Internet-based network connecting multiple facilities with a central data warehouse and server, accessible via standard web-browser. This is an existing infrastructure and Contractor is not required to configure any components of this WAN. Contractor is however required to provide data and services via BACnet over IP or LonTalk over IP to the Owner's WAN.

B. Refer Division 23 Section "BAS Software and Programming" for the naming convention.

2.2 BUILDING CONTROLLER (BC), BACNET

A. The BC shall be a microprocessor-based communications device which acts as a router between the Primary LAN and Supervisory LAN

B. The BC shall perform information translation between the Primary LAN and the Supervisory LAN, supervise communications on a polling supervisory LAN, and shall be applicable to systems in which the same functionality is not provided in the BC.

C. BC shall support interrogation, full control, and all utilities associated with all AACs and ASCs under the Primary Controller LAN.

D. All BACnet Interoperability Building Blocks (BIBBs) are required to be supported for each native BACnet device.

2.3 LOCAL SUPERVISORY LAN INTERFACE DEVICE (LANID) LONTALK

A. Routers shall be a microprocessor-based communications device that provides for access and information translation between the Primary LAN and the Supervisory LAN, which is 100 Mbps Ethernet TCP/IP and shall use LonTalk over IP. The Router shall be transparent to control functions and shall not be required to control information routing on the Primary LAN. Two routers shall be provided for each Primary LAN connection and shall be in parallel for dual access to the Primary LAN as follows:

1. LIP-3ECT routers as manufactured by LoyTec with the following features and capabilities, no exceptions will be allowed:
    a. Provides routing for packets between ANSI/EIA-709 and the IP network.
    b. Provides tunneling of ANSI/EIA-709 packets through the IP network.
    c. Fully EIA-852 compliant.
    d. Built-in EIA-852 configuration server.
    e. Shall support the network analysis tool utilized for the project.
    f. MD5 authentication.
    g. Supports firmware update through serial port, Ethernet and EIA-709 channel.
    h. Supports multiple transceivers: FT-10/LPT-10, TP-1250, RS-485, PLT-22.
    i. Bit-rates between 300 bps and 2.5 Mbps.
    j. May be used as L–Switch compatible collision-less, low-latency backbone.
    k. Status, diagnostic, and activity LEDS for all LANs.

BUILDING AUTOMATION SYSTEM (BAS) - COMMUNICATION DEVICES

l. Built-in web server for configuration of the L-IP and the IP-852 channel.
m. Serial port for configuration.
n. Real-time clock with battery backup.
o. 9-35 VDC / 9-24 VAC supply voltage.
p. Network diagnostics and overview of the network status.
q. Status of the EIA-852 channel and EIA-709 network with the status LEDs.
r. Shall support the remote network analysis tool so the network can be analyzed from any OWS.

2. For LON systems, JACE 512 as manufactured by Tridium or NSX1000e as manufactured by Plexus, no exceptions will be allowed.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF CONTROL SYSTEMS

A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.

B. Contractor shall fully configure and provide all interface devices and software to provide an integrated system.

C. Contractor shall closely coordinate with the Owner, or designated representative, to establish IP addresses and communications to assure proper operation of the building control system with the Owner’s WAN, CSS’s/OWS’s and OWSs.

END OF SECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:
1. System Software.
2. Programming Description.
3. Control Algorithms.
4. Energy Management Applications.
5. Password Protection.
6. Alarm Reporting.
7. Trending.
8. Data Acquisition and Storage.
9. Point Structuring.
10. Dynamic Color Graphics.

1.2 DESCRIPTION OF WORK:

A. Fully configure systems and furnish and install all software, programming and dynamic color graphics for a complete and fully functioning system as specified.

B. Refer to Division 23 Section "Building Automation System (BAS)" for general requirements.

C. Refer to Division 23 Section "Building Automation System (BAS) - Sequence of Operation" for specific sequences of operation for controlled equipment.

D. Provide an allowance of 200 hours of additional programming after project acceptance and occupancy to be completed at the direction of the Owner/Engineer for adjusting system sequences and performance.

1.3 LICENSING

A. Include licensing for all software packages at all required Control System Server (CSS Operator Work Stations (OWS) and Portable Operator Terminal (POT).

B. Any operator interface, programming environment, networking, database management and any other software used by the Contractor to install the system or needed to operate the system to its full capabilities shall be licensed and provided to the Owner.

C. Include licensing for all software packages at all required Web Server and OWS's and POT's. Licensing shall allow access to all aspects of the system including system access, workstations, points, programming, database management, graphics etc. No restrictions shall be placed on the licensing. All operator interfaces, programming environment, networking, database management and any other software used by the Contractor to install the system or needed to operate the system to its full capabilities shall be licensed and provided to the Owner.

D. All software should be available on all Web Servers and OWS's provided, and on all Portable Operator Terminals. Hardware and software keys to provide all rights shall be installed on all workstations. At least 2 sets of CDs shall be provided with backup software for all software provided, so that the Owner may reinstall any software as necessary. Include all licensing for workstation operating systems, and all required third-party software licenses. These backup disks will include a backup of all program data files, graphics etc. and shall allow the owner to completely restore the system in the case of a computer malfunction

E. Provide evidence of licensing including version and original software copies for each WEB Server OWS's and POT's. Licenses shall allow for access to any site device and shall not be restricted to accessing, database management, configuring, etc. the LANs included in this project. The licensing and registration proof will be provided when the system is installed on site.

F. Upgrade all software packages to the release (version) in effect at the end of the Warranty Period and provide a letter indicating the current release/version date at the end of the warranty.

G. Refer to Division 23 Section "Building Automation System (BAS)" for further requirements.

PART 2 - PRODUCTS

2.1 SYSTEM SOFTWARE-GENERAL

A. Functionality and Completeness: The Contractor shall furnish and install all software and programming necessary to provide a complete and functioning system as specified. The Contractor shall include all software and programming not specifically itemized in these Specifications, which is necessary to implement, maintain, operate, and diagnose the system in compliance with these Specifications.

2.2 Controller SOFTWARE

A. All bindings, SNVT's, configuration values, addresses, calibration values, parameters, variables, tuning values, gains, test values, etc. for all software, programs, network configurations etc. shall be exposed and be available for setup, manipulation, adjustment, calibration, testing, etc. at all workstations, CSS's/OWS's, POT's for use as allowed via applicable password protection for all controllers and devices throughout all networks and the entire BAS.

B. Building Controller (BC) Software Residency: Each BC as defined below shall be capable of control and monitoring of all points physically connected to it. All software including the following shall reside and execute at the BC:
1. Real-Time Operating System software
2. Real-Time Clock/Calendar and network time synchronization
3. BC diagnostic software
4. LAN Communication software/firmware
5. Direct Digital Control software
6. Alarm Processing and Buffering software
7. Energy Management software
8. Data Trending, Reporting, and Buffering software
9. I/O (physical and virtual) database
10. Remote Communication software

C. Advanced Aplication Controller (AAC) Application Specific Controller (ASC) Software Residency: Each AAC/ASC as defined below shall be capable of control and monitoring of all points physically connected to it. As a minimum, software including the following shall reside and execute at the AAC/ASC. Other software to support other required functions of the AAC/ASC may reside at the BC or LAN interface device (specified in Division 23 Section "Building Automation System (BAS) - Communication Devices") with the restrictions/exceptions per application provided in Division 23 Section "Building Automation System (BAS) - Field Panels":
1. Real-Time Operating System software
2. AAC/ASC diagnostic software
3. LAN Communication software
4. Control software applicable to the unit it serves that will support a single mode of operation
5. I/O (physical and virtual) database to support one mode of operation

D. Stand Alone Capability: BC shall continue to perform all functions independent of a failure in other BC/AAC/ASC or other communication links to other BCs/AACs/ASCs. Trends and runtime totalization shall be retained in memory. Runtime totalization shall be available on all digital input points that monitor electric motor status. Refer also to Division 23 Section "Building Automation System (BAS) - Field Panels" for other aspects of stand alone functionality..

E. Operating System: Controllers shall include a real-time operating system resident in ROM. This software shall execute independently from any other devices in the system. It shall support all specified functions. It shall provide a command prioritization scheme to allow functional override of control functions. Refer also to Division 23 Section "Building Automation System (BAS) - Field Panels" for other aspects of the controller's operating system.

F. Network Communications: Each controller shall include software/firmware that supports the networking of CUs on a common communications trunk that forms the respective LAN. Network support shall include the following:

1. Controller communication software shall include error detection, correction, and re-transmission to ensure data integrity.
2. LonTalk - Provide a network bandwidth analysis tool. The tool for determining bandwidth utilization shall be the LoyTech protocol analyzer LPA-IP network analysis tool, no exceptions allowed. Turn the tool over to the Owner as part of the Project Closeout requirements.
3. Operator/System communication software shall facilitate communications between other BCs, all subordinate AACs/ASCs, Gateways and LAN Interface Devices or Operator Workstations. Gateways and LAN Interface Devices or CSS's/OWS's. Software shall allow point interrogation, adjustment, addition/deletion, and programming while the controller is on line and functioning without disruption to unaffected points. The software architecture shall allow networked controllers to share selected physical and virtual point information throughout the entire system.

G. Point Database/Summary Table: All points included in the typical equipment point list must be represented in a common, open protocol format. Naming conventions for these points and network addressing are discussed in PART 3 of this Section. Point/system database creation and modification shall be via a user-friendly, menu-driven program. System software shall support virtual or logic point (points not representing a physical I/O) creation. Software shall support virtual points with all services specified herein. Database software shall support definition of all parameters specified in PART 3 of this Section for a given point type. If database does not support all these parameters, software module shall be created and attached to the points which accomplish the respective function.

H. Diagnostic Software: Controller software shall include diagnostic software that checks memory and communications and reports any malfunctions

I. Alarm/Messaging Software: Controller software shall support alarm/message processing and buffering software as more fully specified below.

J. Application Programs: CUs shall support and execute application programs as more fully specified below:
1. All Direct Digital Control software, Energy Management Control software, and functional block application programming software templates shall be provided in a 'ready-to-use' state, and shall not require (but shall allow) the Owner's programming.
2. Line programs shall supply preprogrammed functions to support these energy management and functional block application algorithms. All functions shall be provided with printed narratives and/or flow diagrams to document algorithms and how to modify and use them.

K. Security: Controller software shall support multiple level password access restriction as more fully specified below.

L. Direct Digital Control: Controller shall support application of Direct Digital Control Logic. All logic modules shall be provided pre-programmed with written documentation to support their application. Provide the following logic modules as a minimum:
1. Proportional-Integral-Derivative (PID) control with analog, PWM and floating output
2. Two Position control (Hi or Low crossing with deadband)
3. Single-Pole Double-Throw relay
4. Delay Timer (delay-on-make, delay-on-break, and interval)
5. Hi/Low Selection
6. Reset or Scaling Module
7. Logical Operators (And, Or, Not, Xor)

M. Psychrometric Parameters: Controller software shall provide preprogrammed functions to calculated and present psychrometric parameters (given temperature and relative humidity) including the following as a minimum: Enthalpy, Wet Bulb Temperature.

N. Updating/Storing Application Data: Site-specific programming residing in volatile memory shall be uploadable/downloadable from an OWS or CSS connected locally, to the Primary LAN, to

the Local Supervisory LAN and remotely via the internet and modem and telephone lines as applicable but all must be available. Initiation of an upload or download shall include all of the following methods; Manually, Scheduled, and Automatically upon detection of a loss or change.

O. Restart: System software shall provide for orderly shutdown upon loss of power and automatic restart upon power restoration. Volatile memory shall be retained; outputs shall go to programmed fail (open, closed, or last) position. Equipment restart shall include a user definable time delay on each piece of equipment to stagger the restart. Loss of power shall be alarmed at operator interface indicating date and time.

P. Time Synchronization: Operators shall be able to set the time and date in any device on the network that supports time-of-day functionality. The operator shall be able to select to set the time and date for an individual device, devices on a single network, or all devices simultaneously. Automatic time synchronization shall be provided.

Q. Misc. Calculations: System software shall automate calculation of psychometric functions, calendar functions, kWh/kW, and flow determination and totalization from pulsed or analog inputs, curve-fitting, look-up table, input/output scaling, time averaging of inputs and A/D conversion coefficients.

2.3 PROGRAMMING DESCRIPTION

A. The application software shall be user programmable.

B. This specification generally requires a programming convention that is logical, easy to learn, use, and diagnose. General approaches to application programming shall be provided by one, or a combination, of the following conventions:
   1. Point Definition: provide templates customized for point type, to support input of individual point information. For LON systems use standard LonWorks SNVTs.
   2. Graphical Block Programming: Manipulation of graphic icon ‘blocks’, each of which represents a subroutine, in a functional/logical manner forming a control logic diagram. Blocks shall allow entry of adjustable settings and parameters via pop-up windows. Provide a utility that shall allow the graphic logic diagrams to be directly compiled into application programs. Logic diagrams shall be viewable either off-line, or on-line with real-time block output values.
   3. Functional Application Programming: Pre-programmed application specific programs that allow/require limited customization via ‘fill-in-the-blanks’ edit fields. Typical values would be setpoints gains, associated point names, alarm limits, etc.
   4. Line Programming: Textual syntax-based programming in a language similar to BASIC designed specifically for HVAC control. Subroutines or functions for energy management applications, setpoints, and adjustable parameters shall be customizable, but shall be provided preprogrammed and documented.

C. Provide a means for testing and/or debugging the control programs both off-line and on-line.

2.4 ENERGY MANAGEMENT APPLICATIONS

A. System shall have the ability to perform all of the following energy management routines via preprogrammed function blocks or template programs. As a minimum provide the following whether or not required in the software:
   1. Time-of-Day Scheduling
   2. Calendar-Based Scheduling
   3. Holiday Scheduling
   4. Temporary Schedule Overrides
   5. Optimal Start/Optimal Stop-based on space temperature offset, outdoor air temperature, and building heating and cooling capacitance factors as a minimum
   6. Night Setback and Morning Recovery Control, with ventilation only during occupancy
   7. Economizer Control (enthalpy or dry-bulb)
   8. Peak Demand Limiting and Load Shedding. The demand limiting function will use demand data as the basis for the function and the load shedding program will use space

temperature adjustment or means acceptable to the Owner to provide load shedding response. The function selected for a given location will be made by the Owner.

9. Dead Band Control

B. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow operator customization. For example the load shedding program will allow the operator to determine the spaces to be included in the load shed as well as the duration of the event. Programs shall be applied to building equipment as described in the Division 23 Section "Building Automation System (BAS) - Sequence of Operation."

2.5 PASSWORD PROTECTION

A. Multiple-level password access protection shall be provided to allow the Owner's authorized BAS Administrator to limit workstation control, display and database manipulation capabilities as deemed appropriate for each user, based upon an assigned user name with a unique password.

B. All passwords for the system shall be provided to the Owner including administrator, dealer, or factory level passwords for the systems provided under this project.

C. Passwords shall restrict access to all Control Units.

D. Each user name shall be assigned to a discrete access level. A minimum of five levels of access shall be supported. Alternately, a comprehensive list of accessibility/functionality items shall be provided, to be enabled or disabled for each user.

E. A minimum of 20 user names shall be supported and programmed per the Owner's direction. Provide ability to deactivate passwords without removal of the login and password. The Owner will be provided with the highest level login and password so that the Owner controls the administrative passwords.

F. Operators shall be able to perform only those commands available for the access level assigned to their user name.

G. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving interface device software on-line. This timer will not be the windows system screen saver feature.

2.6 ALARM AND EVENT MANAGEMENT REPORTING

A. Alarm management shall be provided to monitor, buffer, and direct alarms and messages to operator devices and memory files. Each BC shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall a BC's ability to report alarms be affected by either operator activity at an Operator Workstation or local handheld device, or by communications with other panels on the network.

1. Alarm Descriptor: Each alarm or point change shall include that point's English language description, and the time and date of occurrence. In addition to the alarm's descriptor and the time and date, the user shall be able to print, display and store an alarm message to more fully describe the alarm condition or direct operator response.
2. Alarm Prioritization: The software shall allow users to define the handling and routing of each alarm by their assignment to discrete priority levels. A minimum of ten priority levels shall be provided. For each priority level, users shall have the ability to enable or disable an audible tone whenever an alarm is reported and whenever an alarm returns to normal condition. Users shall have the ability to manually inhibit alarm reporting for each individual alarm and for each priority level. Contractor shall coordinate with the Owner on establishing alarm priority definitions.
3. Alarm Report Routing: Each alarm priority level shall be associated with a unique user-defined list of operator devices including any combination of local or remote workstations, printers and workstation disk files. All alarms associated with a given priority level shall be routed to all operator devices on the user-defined list associated with that priority level. For each priority level, alarms shall be automatically routed to a default operator device in the

event that alarms are unable to be routed to any operator device assigned to the priority level.

4. Auto-Dial Alarm Routing: For alarm priority levels that include a remote workstation (accessed by modem) as one of the listed reporting destinations, the BC shall initiate a call to report the alarm, and shall terminate the call after alarm reporting is complete. System shall be capable of multiple retries and buffer alarms until a connection is made. If no connection is made, system shall attempt connection to an alternate dial-up workstation. System shall also be able to dial multiple pagers upon alarm activation.
5. Alarm Acknowledgment: For alarm priority levels that are directed to a workstation screen, an indication of alarm receipt shall be displayed immediately regardless of the application in use at the workstation, and shall remain on the screen until acknowledged by a user having a password that allows alarm acknowledgment. Upon acknowledgment, the complete alarm message string (including date, time, and user name of acknowledging operator) shall be stored in a selected file on the workstation hard disk.
6. Alarm Display: All alarms will popup as described in Alarm Acknowledgement. The owner will have the option to limit the pop up alarms based on alarm priority.

B. It shall be possible for any operator to receive a summary of all alarms, regardless of acknowledgement status; for which a particular recipient is enrolled for notification; based on current event state; based on the particular event algorithm (e.g., change of value, change of state, out of range, and so on); alarm priority; and notification class.

C. Alarm Historical Database: The database shall store all alarms and events object occurrences in an ODBC or an OLE database-compliant relational database. Provide a commercially available ODBC driver or OLE database data provider, which would allow applications to access the data using standard Microsoft Windows Data Services.

2.7 TRENDING

A. The software shall display historical data in both a tabular and graphical format. The requirements of this trending shall include the following:
1. Trends may be buffered in the BC as long as the trend data in the BC and the historical data stored on hard disk is displayed seamlessly.
2. Provide trends for all physical points, virtual points and calculated variables.
3. Trend data shall be stored in relational database format as specified in herein under Data Acquisition and Storage.
4. In the graphical format, the trend shall plot at least 8 different values for a given time period superimposed on the same graph. The 8 values shall be distinguishable by using unique colors. In printed form the 8 lines shall be distinguishable by different line symbology. Displayed trend graphs shall indicate the engineering units for each trended value.
5. The sample rate and data selection shall be selectable by the operator.
6. The trended value range shall be selectable by the operator.
7. Where trended values on one table/graph are COV, software shall automatically fill the trend samples between COV entries.

B. Control Loop Performance Trends: Controllers incorporating PID control loops shall also provide high resolution sampling in less than six second increments for verification of control loop performance.

C. Data Buffering and Archiving: Trend data may be buffered at the BC, and uploaded to hard disk storage for archiving as needed based on the BC’s memory constraints. All archived trends shall be transmitted to the on-site OWS as applicable. Uploads shall occur based upon a user-defined interval, manual command, or automatically when the trend buffers become full.

D. Time Synchronization: Provide a time master that is installed and configured to synchronize the clocks of all devices supporting time synchronization. Synchronization shall be done using Coordinated Universal Time (UTC). All trend sample times shall be able to be synchronized. The frequency of time synchronization message transmission shall be selectable by the operator.

E. Graphic displays shall have the capacity to trend a minimum of 200 points simultaneously and 8 separate points on a single display.

2.8 Dynamic Plotting

A. Provide a utility to dynamically plot in real-time at least 4 values on a given 2-dimensional dynamic plot/graph with at least two Y-axes. At least 5 dynamic plots shall be allowed simultaneously.

2.9 Data acquisition and Storage

A. All points included in the typical equipment point list must be represented in a common, open or accessible format. Naming conventions for these points and network addressing are discussed in the 'Point Naming Conventions' paragraph below.

B. Data from the BAS shall be stored in relational database format. The format and the naming convention used for storing the database files shall remain consistent across the database and across time. The relational structure shall allow for storage of any additional data points, which are added to the BAS in future. The metadata/schema or formal descriptions of the tables, columns, domains, and constraints shall be provided for each database.

C. The database shall allow applications to access the data while the database is running. The database shall not require shutting down in order to provide read-write access to the data. Data shall be able to be read from the database without interrupting the continuous storage of trend data being carried by the BAS.

D. The database shall be ODBC or OLE database compliant. Provide a commercially-available ODBC driver or OLE database data provider, which would allow applications to access the data via Microsoft Windows standard data access services.

2.10 TOTALIZATION

A. The software shall support totalizing analog, digital, and pulsed inputs and be capable of accumulating, storing, and converting these totals to engineering units used in the documents. These values shall generally be accessible to the Operator Interfaces to support management-reporting functions.

B. Totalization of electricity use/demand shall allow application of totals to different rate periods, which shall be user definable.

C. When specified to provide electrical or utility Use/Demand, the Contractor shall obtain from the local utility all information required to obtain meter data, including k factors, conversion constants, and the like.

2.11 EQUIPMENT SCHEDULING

A. Provide a graphic utility for user-friendly operator interface to adjust equipment-operating schedules.

B. Scheduling feature shall include multiple seven-day master schedules, plus holiday schedule, each with start time and stop time. Master schedules shall be individually editable for each day and holiday.

C. Scheduling feature shall allow for each individual equipment unit to be assigned to one of the master schedules.

D. Timed override feature shall allow an operator to temporarily change the state of scheduled equipment. An override command shall be selectable to apply to an individual unit, all units assigned to a given master schedule, or to all units in a building. Timed override shall terminate at the end of an operator selectable time, or at the end of the scheduled occupied/unoccupied period, whichever comes first. A password level that does not allow assignment of master schedules shall allow a timed override feature.

E. A yearly calendar feature shall allow assignment of holidays, and automatic reset of system real time clocks for transitions between daylight savings time and standard time.

2.12 POINT STRUCTURING AND NAMING

A. General: The intent of this Section is to require a consistent means of naming points across the the Owner requirements. Contractor shall configure the systems from the perspective of the Enterprise, not solely the local project. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, and the like. The interface shall always use this naming convention. The naming convention shall be implemented as much as practical, and any deviations from this naming convention shall be approved by the Owner.

B. Point Summary Table
   1. The term 'Point' is a generic description for the class of object represented by analog and binary inputs, outputs, and values.
   2. With each schematic, Contractor shall provide a Point Summary Table listing:
      a. Building number and abbreviation
      b. System type
      c. Equipment type
      d. Point suffix
      e. Full point name (see Point Naming Convention paragraph)
      f. English language point description
      g. Ethernet backbone network number,
      h. Network number
      i. Device ID
      j. Device MAC address
      k. Engineering units
   3. Point Summary Table shall be provided in both hard copy and in electronic format (ODBC-compliant).
   4. Point Summary Table shall also illustrate Network Variables/LonWorks Bindings.
   5. The Contractor shall coordinate with the Owner's representative and compile and submit a proposed Point Summary Table for review prior to any object programming or project startup.
   6. The Point Summary Table shall be kept current throughout the duration of the project by the Contractor as the Master List of all points for the project. Project closeout documents shall include an up-to-date accurate Point Summary Table. The Contractor shall deliver to the Owner the final Point Summary Table prior to final acceptance of the system. The Point Summary Table shall be used as a reference and guide during the commissioning process.
   7. The Point Summary Table shall contain all data fields on a single row per point. The Point Summary Table is to have a single master source for all point information in the building that is easily sorted and kept up-to-date. Although a relational database of Device ID-to-point information would be more efficient, the single line format is required as a single master table that will reflect all point information for the building. The point description shall be an easily understandable English-language description of the point.
   8. Point Summary Table shall also illustrate Network Variables/BACnet Data Links/LonWorks Bindings.

Point Summary Table Example
Row Headers and Examples
(Transpose for a single point per row format)

Building Number	0006 (the Owner's 4 digit Building Code)
System Type	Cooling
Equipment Type	Chiller
Point Suffix	CHLR1KW
*Point Name (Object Name)	0006.COOLING.CHILLER.CHLR1KW
*Point Description (Object Description)	Chiller 1 kW
Ethernet Network Number	600
Network Number	610
Device ID	1024006
Device MAC address	24
Point Type	AI
Instance Number	4
Engineering Units	KW
Network Variable?	True
Server Device	1024006
Client Devices	1028006

* Represents information that shall reside in the property for the point

C. Point Naming Convention
1. All point names shall adhere to the format as established below. Said objects shall include all physical I/O points, calculated points used for standard reports, and all application program parameters. For each BAS point, a specific and unique name shall be required.
2. For each point, four (4) distinct descriptors shall be linked to form each unique object name: Building, System, Equipment, and Point. All keyboard characters except a space are allowable. Each of the four descriptors must be bound by a period to form the entire object name. Reference the paragraphs below for an example of these descriptors.
3. The Owner shall designate the *Building* descriptor. The *System* descriptor shall further define the object in terms of air handling, cooling, heating, or other system. The *Equipment* descriptor shall define the equipment category; e.g., Chiller, Air Handler, or other equipment. The *Point* descriptor shall define the hardware or software type or function associated with the equipment; e.g., supply temperature, water pressure, alarm, mixed air temperature setpoint, etc. and shall contain any numbering conventions for multiples of equipment; e.g., CHLR1KW, CHLR2KW, BLR2AL (Boiler 2 Alarm), HWP1ST (Hot Water Pump 1 Status).
4. A consistent object (point) naming convention shall be utilized to facilitate familiarity and operational ease across the Owner's WAN. Inter-facility consistency shall be maintained to ensure transparent operability to the greatest degree possible. The table below details the object naming convention and general format of the descriptor string.

Point Name Requirements

Descriptors		Comment
Building Number	0006	The Master Building List also has the correct number for each building.
System	AIRHANDLING EXHAUST HEATING COOLING UTILITY ENDUSE MISC	 Boilers and ancillary equipment Chillers and ancillary equipment Main electrical and gas meters Specific building loads by type
Equipment	AHU-1 BOILERS CHILLERS FACILITY TOWERS WEATHER	 Non-specific boiler system points Non-specific chiller system points
Point Suffix	See Input/Output point summary table for conventions	

5. Examples: Within each point name, the descriptors shall be bound by a period. Within each descriptor, words shall not be separated by dashes, spaces, or other separators as follows:
   a. 0006.COOLING.CHILLERS.CHWP1ST
   b. 0006.HEATING.BOILERS.BLR1CFH

D. Device Addressing Convention:
   1. Lontalk - Network numbers and SNVT's shall be unique throughout the network.
   2. BACnet - Network numbers and Device Object IDs shall be unique throughout the network.
   3. BACnet - For each BAS object, a specific and unique BACnet object name shall be required.
   4. All assignment of network numbers and Device Object IDs shall be coordinated with the Owner.
   5. Each Network number shall be unique throughout all facilities and shall be assigned in the following manner unless specified otherwise:
      a. BBBFF, where: BBB = 1-655 assigned to each building, FF = 00 for building backbone network, 1-35 indicating floors or separate systems in the building.
   6. Each Device Identifier property shall be unique throughout the system and shall be assigned in the following manner unless specified otherwise:
      a. XXFFBBB, where: XX = number 0 to 40, FF = 00 for building backbone network, 1-35 indicating floors or separate systems in the building. BBB = 1-655 assigned to each building.
   7. The Contractor shall coordinate with the Owner or a designated representative to ensure that no duplicate Device Object IDs occur.
   8. Alternative Device ID schemes or cross project Device ID duplication if allowed shall be approved before project commencement by the Owner.

2.13 OPERATOR INTERFACE GRAPHIC SOFTWARE

A. Graphic software shall facilitate user-friendly interface to all aspects of the System Software specified above. The intent of this specification is to require a graphic package that provides for intuitive operation of the systems without extensive training and experience. It shall facilitate logical and simple system interrogation, modification, configuration, and diagnosis.

B. Graphic software shall support multiple simultaneous screens to be displayed and resizable in a 'Windows'-like environment. All functions excepting text entry functions shall be executable with a mouse.

C. Graphic software shall provide for multitasking such that third-party programs can be used while the OWS software is on line. Software shall provide the ability to alarm graphically even when operator is in another software package.

D. Operating system software shall be Windows 7 or 8.

E. The software shall allow for the Owner's creation of user-defined, color graphic displays of geographic maps, building plans, floor plans, and mechanical and electrical system schematics. These graphics shall be capable of displaying all point information from the database including any attributes associated with each point (i.e., engineering units, etc.). In addition, operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse.

F. Screen Penetration: The operator interface shall allow users to access the various system graphic screens via a graphical penetration scheme by using the mouse to select from menus or 'button' icons. All screens will be accessible out the use of outline type selection screens. Each graphic screen shall be capable of having a unique list of other graphic screens that are directly linked through the selection of a menu item or button icon.

G. Dynamic Data Displays: Dynamic physical point values shall automatically updated at a minimum frequency of 6 updates per minute without operator intervention. Point value fields shall be displayed with a color code depicting normal, abnormal, override and alarm conditions.

H. Point Override Feature: Provide the following:
   1. An Operator from a work-station shall have the capability to place an end device under manual control, which shall prevent the control logic from making changes to the end device status, and provide the operator with the ability to position the end device. It must be possible to put a point under manual control and command the point to a specific state or value from a graphic page. Once under manual control the point will be able to be realeased to automatice operation from the same graphics page. See the definition of Manual Control in the definition of terms Article in this Section.
   2. An Operator from the operator work-station shall have the capability to place a sensor input into test mode. When in test mode, any changes from the physical sensor will no longer be recognized and the value reported to control logic shall take a value that is assigned to it by the operator from the operator work-station. It must be possible to put a point in test and assign a test value from a graphic page. See the definition of Test Mode in the definition of terms Article of this Section.
   3. Points that are overridden shall be reported as an alarm, and shall be displayed in a coded color. The alarm message shall include the operator's user name. A list of points that are currently in an override state shall be available through menu selection. Such overrides or changes shall occur in the control unit, not just in the workstation software. The graphic point override feature shall be subject to password level protection.

I. Dynamic Symbols: Provide a selection of standard symbols that change in appearance based on the value of an associated point.
   1. Analog symbol: Provide a symbol that represents the value of an analog point as the length of a line or linear bar. Digital symbol: Provide symbols such as switches, pilot lights, rotating fan wheels, etc. to represent the value of digital input and output points. Point Status Color: Graphic presentations shall indicate different colors for different point statuses. (For instance, green = normal, red = alarm, gray (or '???') for non-response.

J. Graphics Development Package: Graphic development and generation software shall be provided to allow the user to add, modify, or delete system graphic displays. The application of the graphic editing will be controlled by password level at the programmer level or higher.
   1. The Contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), mechanical system components (e.g., pumps, chillers, cooling towers, boilers, etc.), complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.) and electrical symbols.

2. The Graphic Development Package shall use a mouse or similar pointing device to allow the user to perform the following:
    a. Define symbols
    b. Position items on graphic screens
    c. Attach physical or virtual points to a graphic
    d. Define background screens
    e. Define connecting lines and curves
    f. Locate, orient and size descriptive text
    g. Define and display colors for all elements
    h. Establish correlation between symbols or text and associated system points or other displays.
    i. Create hot spots or link triggers to other graphic displays or other functions in the software.

PART 3 - EXECUTION

3.1 SYSTEM CONFIGURATION

A. Contractor shall thoroughly and completely configure the BAS software, supplemental software, network communications, CSS, OWS, printer, and remote communications for a fully complete operational system.

3.2 SITE-SPECIFIC APPLICATION PROGRAMMING

A. Provide all database creation and site-specific application control programming as required by these Specifications, national and local standards and for a fully functioning system. Contractor shall provide all initial site-specific application programming and thoroughly document programming. Generally meet the intent of the written sequences of operation. If a sequence is not clear, in the contractors opinion, it is the Contractor's responsibility to request clarification..

B. All site-specific programming shall be fully documented and submitted for review and approval, both prior to downloading into the panel, at the completion of functional performance testing, and at the end of the warranty period.

C. All programming, graphics and data files must be maintained in a logical system of directories with self-explanatory file names. All files developed for the project will be the property of the Owner and shall remain on the workstation(s)/server(s) at the completion of the project.

3.3 PASSWORD SETUP

A. Set up the following password levels to include the specified capabilities:
    1. Level 1: (the Owner's BAS Administrator)
        a. Level 2 capabilities
        b. View, add, change and delete user names, passwords, password levels
        c. All unrestricted system capabilities including all network management functions.
    2. Level 2: (Programmer)
        a. Level 3 capabilities
        b. Configure system software
        c. Modify control unit programs
        d. Modify graphic software
        e. Essentially unrestricted except for viewing or modifying user names, passwords, password levels
    3. Level 3: (Chief Engineer)
        a. Level 4 capabilities
        b. Override output points
        c. Change all setpoints and reset schedules.
        d. Exit BAS software to use third party programs
    4. Level 4: (Assitant)
        a. Level 5 capabilities
        b. Acknowledge alarms

c. Change equipment schedules
d. Change room temperature setpoints

5. Level 5: (Veiw only Access)
   a. Display all graphic data
   b. Trend point data
   c. Unless otherwise directed the Login will be the Owner's name and the password will be "ownerswebaccess".

B. Contractor shall assist the Owner's operators with assigning user names, passwords and password levels. There may be multiple login name and passwords for a given password level. The contractor will be responsible for changing BAS administrator and Programmer level passwords if those are accidentally provided to other contractors or the Owner.

3.4 POINT PARAMETERS

A. Provide the following minimum programming for each analog input:
1. Name
2. Address
3. Scanning frequency or COV threshold
4. Engineering units
5. Offset calibration and scaling factor for engineering units
6. High and low alarm values and alarm differentials for return to normal condition
7. High and low value reporting limits (reasonableness values), which shall prevent control logic from using shorted or open circuit values.
8. Default value to be used when the actual measured value is not reporting. This is required only for points that are transferred across the primary and/or secondary controlling networks and used in control programs residing in control units other than the one in which the point resides. Events causing the default value to be used shall include failure of the control unit in which the point resides, or failure of any network over which the point value is transferred. All default values will be provided in list format for evaluation by the Owner.
9. Selectable averaging function that shall average the measured value over a user selected number of scans for reporting.

B. Provide the following minimum programming for each analog output:
1. Name
2. Address
3. Output updating frequency
4. Engineering units
5. Offset calibration and scaling factor for engineering units
6. Output Range
7. Default value to be used when the normal controlling value is not reporting.

C. Provide the following minimum programming for each digital input:
1. Name
2. Address
3. Engineering units (on/off, open/closed, freeze/normal, etc.)
4. Debounce time delay
5. Message and alarm reporting as specified
6. Reporting of each change of state, and memory storage of the time of the last change of state
7. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.

D. Provide the following minimum programming for each digital output:
1. Name
2. Address
3. Output updating frequency
4. Engineering units (on/off, open/closed, freeze/normal, etc.)
5. Direct or Reverse action selection

6. Minimum on-time
7. Minimum off-time
8. Status association with a DI and failure alarming (as applicable)
9. Reporting of each change of state, and memory storage of the time of the last change of state.
10. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.
11. Default value to be used when the normal controlling value is not reporting.

3.5 Trends

A. Contractor shall establish and store trend logs. Trend logs shall be prepared for each physical input and output point. All dynamic virtual points such as setpoints subject to a reset schedule, intermediate setpoint values for cascaded control loops, and the like will be trended as directed by the Owner

B. The Owner will analyze trend logs of the system operating parameters to evaluate normal system functionality. Contractor shall establish these trends and ensure they are being stored properly.
   1. Data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field or single date stamp. Recorded parameters for a given piece of equipment or component shall be trended at the same intervals and be presented in a maximum of two separate 2-dimensional formats with time being the row heading and field name being the column heading.

C. Sample times indicated as COV (±) or change-of-value mean that the changed parameter only needs to be recorded after the value changes by the amount listed. When outputting to the trending file, the latest recorded value shall be listed with any given time increment record. The samples shall be filled with the latest values also if the points include different time intervals. If the BAS does not have the capability to record based on COV, the parameter shall be recorded based on the interval common to the unit.

D. Trending intervals or COV thresholds shall be dictated by the Owner or their representative, upon system start-up.

E. The Contractor shall demonstrate functional trends as specified for a period of 30 days after successful system demonstration before final acceptance of the system. The trend limit is 1 year from demonstration for LEED projects that require trend data for M&V purposes. The limit on the length of trend data will be a function of the storage capacity of the computer.

3.6 TREND GRAPHS

A. Prepare controller and workstation software to display graphical format trends. Trended values and intervals shall be the same as those specified

B. Lines shall be labeled and shall be distinguishable from each other by using either different line types, or different line colors.

C. Provide a legend identifying the line color and symbol along side the point noun name for each point in the trend. Aslo, indicate engineering units of the y-axis values; e.g. degrees F., inches w.g., Btu/lb, percent open, etc.

D. The y-axis scales shall be chosen so that all trended values are in a readable range. Do not mix trended values on one graph if their unit ranges are incompatible.

E. Trend outside air temperature, humidity, and enthalpy during each period in which any other points are trended except for control loop performance trends.

F. Allow point groups to be saved for future trends. For example HW supply and return temperatures along with HX stm valve position and pump status.

3.7 ALARMS

A. Override Alarms: Any point that is overridden through the override feature of the graphic workstation software shall be reported as a Level 3 alarm.

B. Analog Input Alarms: For each analog input, program an alarm message for reporting whenever the analog value is outside of the programmed alarm limits. Report a 'Return-to-Normal' message after the analog value returns to the normal range, using a programmed alarm differential. The alarm limits shall be individually selected by the Contractor based on the following criteria:
   1. Space temperature, except as otherwise stated in sequence of operation: Level 3
      a. Low alarm: 64°F
      b. Low return-to-normal: 68°F
      c. High alarm: 85°F
      d. High return-to-normal: 80°F
   2. Controlled media temperature other than space temperature (e.g. AHU discharge air temperature, steam converter leaving water temperature, condenser water supply, chilled water supply, etc.): Level 3 (If controlled media temperature setpoint is reset, alarm setpoints shall be programmed to follow setpoint)
      a. Low alarm: 3°F below setpoint
      b. Low return-to-normal: 2°F below setpoint
      c. High alarm: 3°F above setpoint
      d. High return-to-normal: 2°F above setpoint.
   3. AHU mixed air temperature: Level 4
      a. Low alarm: 45°F
      b. Low return-to-normal: 46°F
      c. High alarm: 90°F
      d. High return-to-normal: 89°F
   4. Duct Pressure:
      a. Low alarm: 0.5"w.g. below setpoint
      b. Low return-to-normal: 0.25"w.g. below setpoint
      c. High alarm: 0.5"w.g. above setpoint
      d. High return-to-normal: 0.25"w.g. above setpoint
   5. Space humidity:
      1) Low alarm: 35%
      2) Low return-to-normal: 40%
      3) High alarm: 75%
      4) High return-to-normal: 70%

C. Status versus Command Alarms: The Sequences of Operation are based on the presumption that motor starter Hand-Off-Auto (HOA) switches are in the 'Auto' position. BAS shall enunciate the following Level 5 alarm message if status indicates a unit is operational when the run command is not present or vice versa:
   1. *DEVICE XXXX* FAILURE: Status is indicated on *{the device}* even though it has been commanded to stop. Check the HOA switch, control relay, status sensing device, contactors, and other components involved in starting the unit. Acknowledge this alarm when the problem has been corrected.

D. Maintenance Alarms: Enunciate Level 5 alarms when runtime accumulation exceeds a value specified by the operator.
   1. *DEVICE XXXX REQUIRES MAINTENANCE*. Runtime has exceeded specified value since last reset.

E. See requirements for additional equipment-specific alarms specified in Division 23 Section "Building Automation System (BAS) - Sequences of Operation."

3.8 GRAPHIC SCREENS

A. Main Screen: The Main screen will be the first screen displayed after login, no navigation required to get to the main screen (see Exhibit A for sample screens). This screen will have the following features:
   1. The Owner will have the option of providing a picture for the background.

2. There will be a link button to the floor plans, Summary screen, and system schematic screens. In the event that there are more 10 to 15 AHU, Boiler and Chiller screens a button to groups of AHU's will be provided.
3. Manufacturer/Installer Logo or information is not to be included in the screen.
4. Provide a global command to open heating or cooling valves to facilitate Test Adjust and Balance. The command will be grouped so that an AHU can be balanced as well as total system balancing. The same function will apply for VAV AHU's were all the boxes can be set at minimum or maximum flow.

B. Floor Plan Screens: The contract document drawings will be made available to the Contractor in AutoCAD format upon request. These drawings may be used only for developing backgrounds for specified graphic screens; however the Owner does not guarantee the suitability of these drawings for the Contractor's purpose (see Exhibit B for sample screens). .
   1. Provide graphic floor plan screens for each floor and/or wing of the building. Indicate the location of all equipment that is not located on the equipment room screens.
      a. Indicate the location of temperature sensors associated with each temperature-controlled zone (i.e., VAV terminals, fan-coils, single-zone AHUs, etc.) on the floor plan screens.
      b. Display the space temperature point adjacent to each temperature sensor symbol along with the room set point. Use a distinct line symbol to demarcate each terminal unit zone boundary. Use distinct background colors for each zone to demarcate the air-handling unit to which it is associated.
      c. Indicate room numbers as provided by the Owner. Verify final room number/name assignments, as these are often different than initially assigned room numbers on the contract drawings.
      d. Provide a drawing link from each space temperature sensor symbol and equipment symbol shown on the graphic floor plan screens to each corresponding zone equipment schematic graphic screen. Because the area available for the floor plans varies from system to system, the size of text used to display data such as room number and temperature will be at least 1/8" high on the screen when the entire floor plan section is displayed.
      e. The floor plan graphics will also indicate the location of control panels. For control devices such as duct smoke detectors, system pressure or differential pressure sensors (water or air), airflow stations that are located outside the equipment rooms. All of these devices will be linked to the associated system graphic. For terminal units the link to the associated system graphic is sufficient and the associated unit control devices do not need to be located on the floor plan.
   2. Provide graphic floor plan screens for each mechanical equipment room and a plan screen of the roof. Indicate the location of each item of mechanical equipment. Provide a drawing link from each equipment symbol shown on the graphic plan view screen to each corresponding mechanical system schematic graphic screen.
   3. Provide a graphic building key plan that will allow navigation at a floor level or from floor to floor. Use elevation views and/or plan views as necessary to graphically indicate the location of all of the larger scale floor plans. Link graphic building key plan to larger scale partial floor plans. Provide links from each larger scale graphic floor plan screen to the building key plan and to each of the other graphic floor plan screens.
   4. When there is more than one building, provide a graphic site plan with links to and from each building plan.

C. System Schematic Screens: Provide graphic system schematic screen for each HVAC subsystem (AHU) controlled with each I/O point in the project appearing on at least one graphic screen. System graphics shall be have the same look as the submittal diagrams (do not use three dimensional graphics) with status, setpoints, current analog input and output values, operator commands, etc. as applicable. Input/output devices shall be shown in their schematically correct locations with the associated value, noun name and engineering units. The position of valves or dampers will be % OPEN. For three way valves it will be %OPEN to

the device. The noun name (English language descriptors) shall be included for each point on all graphics; this may be accomplished by the use of a pop-up window accessed by selecting the displayed point with the mouse. Indicate all adjustable setpoints on the applicable system schematic graphic screen or, if space does not allow, on a supplemental linked-setpoint screen. Similar AHU's will have the same organization of information. For example a single zone AHU will not put all the set points across the top and multizone put them on the side or bottom (see Exhibit C for sample screens).

1. Provide graphic screens for each air handling system. Indicate outside air temperature and enthalpy, and mode of operation as applicable (i.e., occupancy mode and heating, cooling, economizer etc based on the sequence of operations). Link screens for air handlers to the heating system and cooling system graphics. Link screens for supply and exhaust systems if they are not combined onto one screen.
2. Provide a graphic screen for each zone with the associated control devices or terminal unit with a link to the associated system schematic screen of the air handling unit that serves the zone.
3. Provide a cooling system graphic screen showing all points associated with the chillers, cooling towers and pumps. Indicate outside air dry-bulb temperature and calculated wet-bulb temperature. Link the chilled water and condenser water systems screens if they cannot fit onto one cooling plant graphic screen.
4. Link the heating and cooling system graphics to utility history reports showing current and monthly electric uses, demands, peak values, and other pertinent values.
5. For each system schematic screen, including AHU, Boiler, Chiller and terminal unit screen, provide a button linked to a text version of the sequence of operation for the device or system. The sequence will be updated with the as-built sequence following completion of the demonstration.

D. System Summary Screens: On each graphic System Screen, provide drawing links to the graphic air handling unit schematic screens (see Exhibit D for sample screens).

1. Provide a chilled water valve screen showing the analog output signal of all chilled water valves with signals expressed as percentage of fully open valve (percentage of full cooling). Indicate the discharge air temperature and setpoint of each air handling unit, cooling system chilled water supply and return temperatures and the outside air temperature and humidity on this graphic. Provide drawing links between the graphic cooling plant screen and this graphic screen.
2. Provide a heating water valve screen showing the analog output signal of all air handling unit heating water valves with signals expressed as percentage of fully open valve (percentage of full heating). Indicate the temperature of the controlled medium (such as AHU discharge air temperature or zone hot water supply temperature) and the associated setpoint and the outside air temperature and humidity.
3. When there are more than four AHU's on the system provide a summary screen with the following type of information for each AHU, each fan command, status, alarms (smoke, freeze, duct static), DAT and duct pressure if applicable. For the heating system provide status and supply water temp or steam pressure and for the chiller provide status and chilled water supply temperature.
4. Provide a BAS system summary screen using the control system riser diagram to show the communication status of all controllers (BC, AAC and ASC's) on the BAS as well as all interface devices such as VFD's, chillers and boiler panels etcetera. Use green board concept, green means communicating, red is not communicating.
5. Provide a terminal unit summary screen grouped by floor or AHU. If the summary is grouped by floor then the AHU will be shown for each terminal unit and vice versa. The points shown will depend on the type of terminal unit and will include room name, floor or AHU, room set point and temperature, DAT, valve position, command status, alarm and occupancy state.
6. Exhaust fans will be show in a table format showing the command signal, the status, the alarm condition, and the occupancy state.

E. Alarms: Each programmed alarm shall appear on at least one graphic screen. In general, alarms shall be displayed on the graphic system schematic screen for the system that the alarm is associated with (for example, chiller alarm shall be shown on graphic cooling system schematic screen). For all graphic screens, display analog values that are in a 'high alarm' condition in a red color, 'low alarm' condition in a blue color. Indicate digital values that are in alarm condition in a red color. When an alarm first occurs it shall "popup" over the current screen so that the operator is imediatedly aware of an alarm.
   1. Maintenance Alarms
      a. Runtime alarm screen will list all equipment with a BAS status. For each piece of equipment the screen will display the current run time (since the last reset), the runtime alarm limit (adj.), its alarm status (red / green) and the total accumulated runtime. The total accumulated runtime would only be zeroed out if the equipment were replaced. For equipment with internal runtime meters ensure that the total accumulative runtime is synchronized.

F. Utility Metering: Provide a graphic for the gas, electric and water utility data required in the sequence of operations. This may entail multiple screens if submetering of the gas or electric usage is included in the project.

END OF SECTION

BUILDING AUTOMATION SYSTEM (BAS) – SOFTWARE AND PROGRAMMING EXHIBITS

EXHIBIT A Main Screen Example Graphics

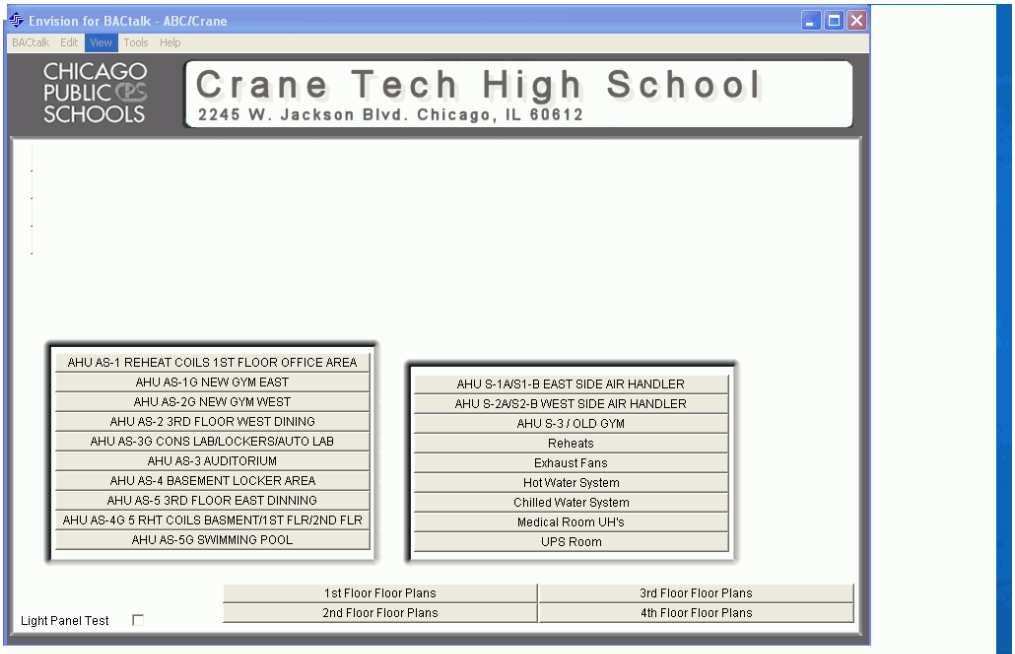
EXHIBIT B Floor Plan Example Graphics

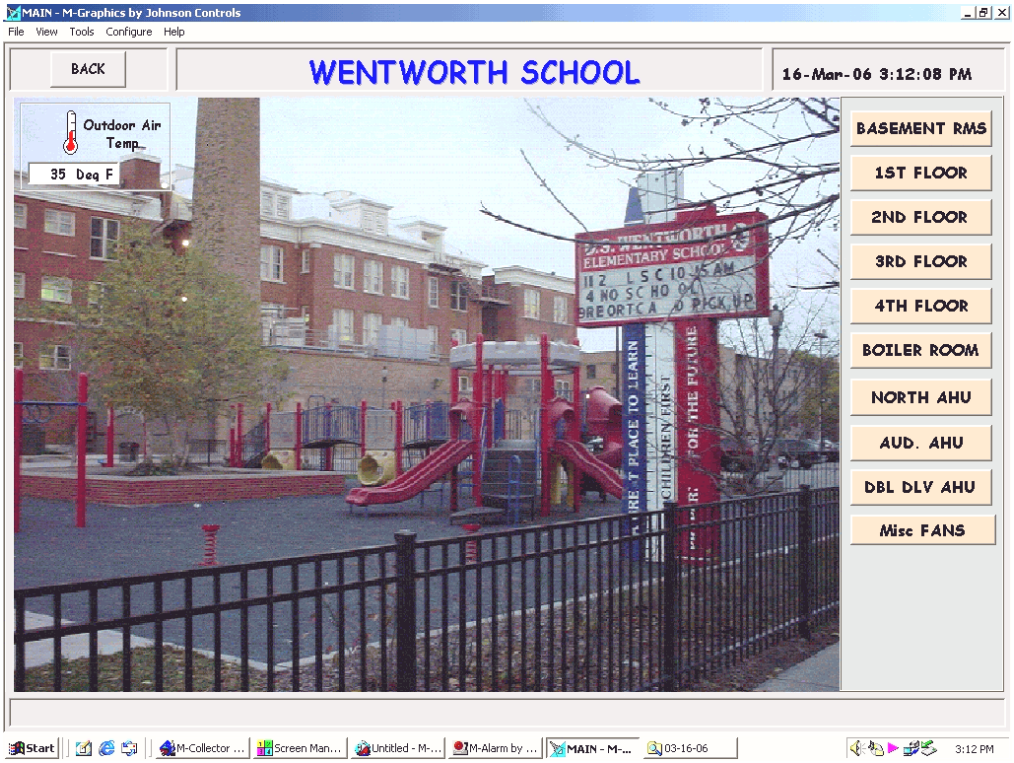
EXHIBIT C System Schematic Example Graphics

EXHIBIT D System Summary Example Graphics

The following graphic screens are provided as examples that incorporate most of the requirements of Division 23 Section "Building Automation System (BAS) – Software and Programming." While few graphic screens meet all the requirements they are illustrative of the quality of graphic screen that Owner expects on projects executed under this specification.

EXHIBIT A Main Screen Example Graphics





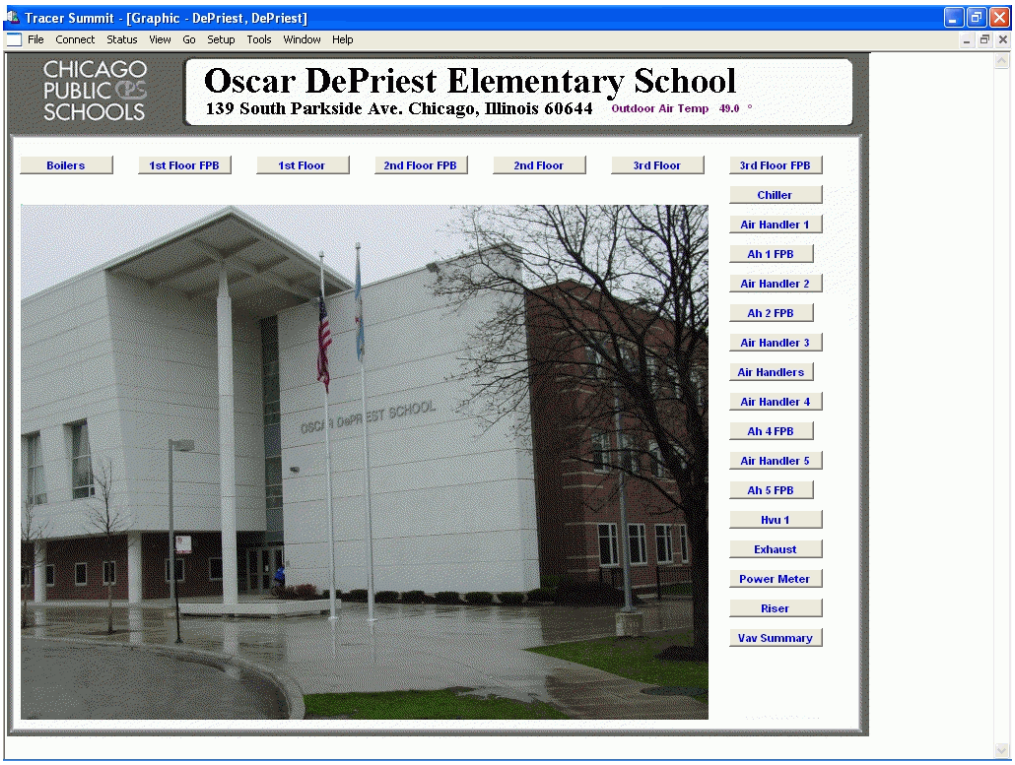
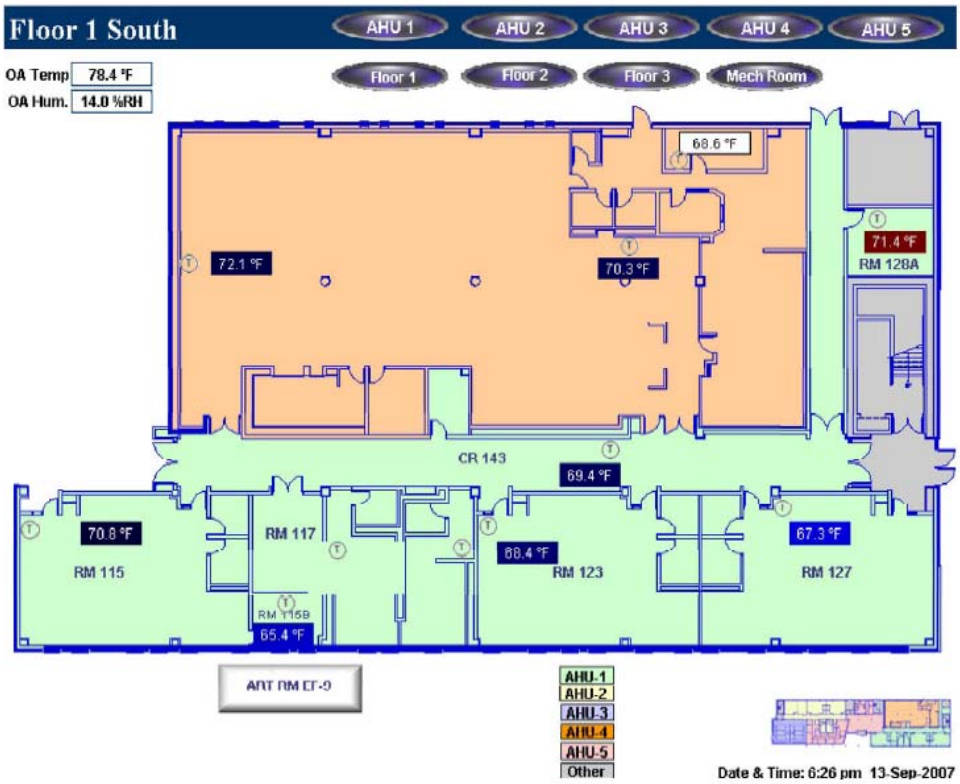
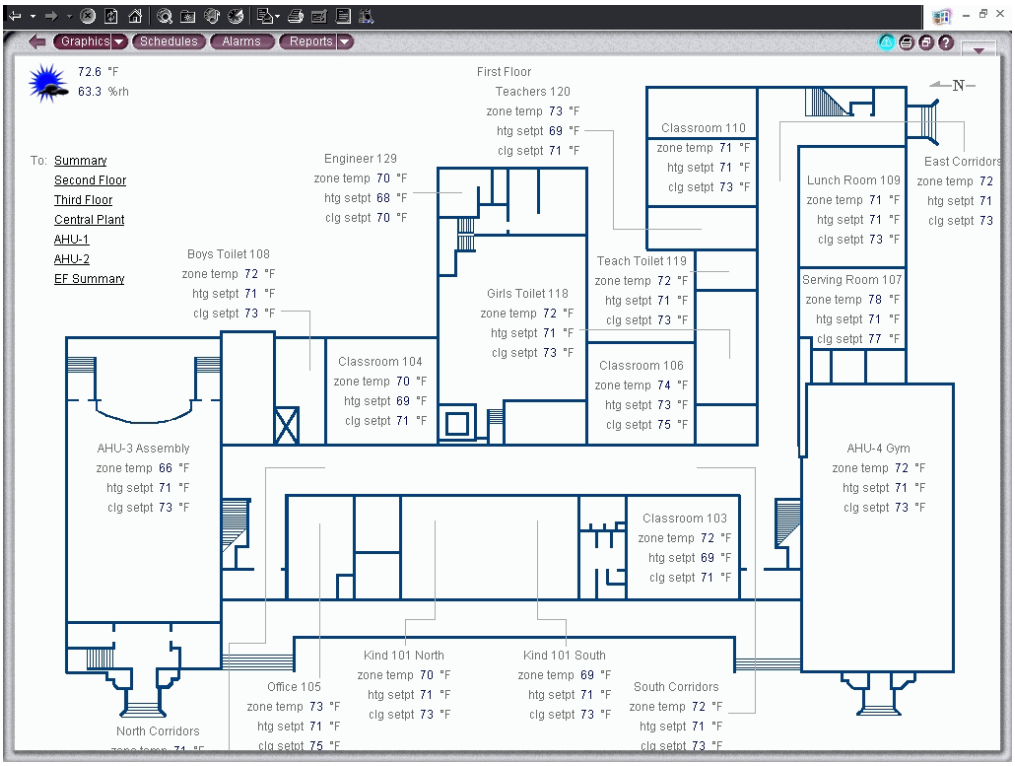
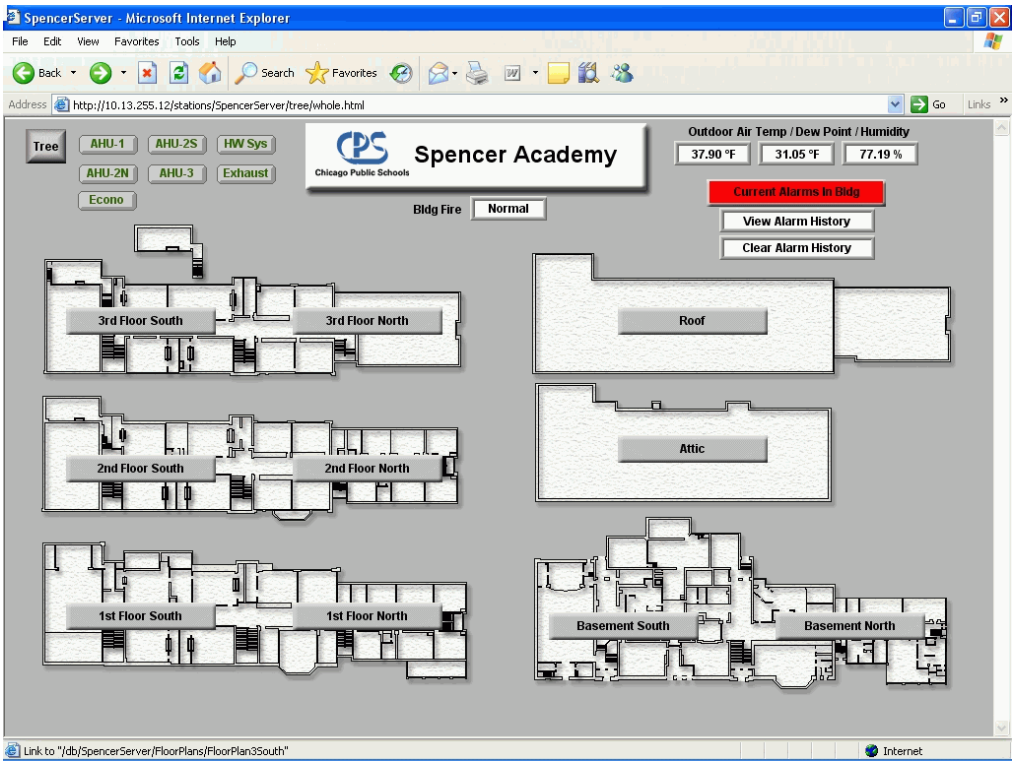
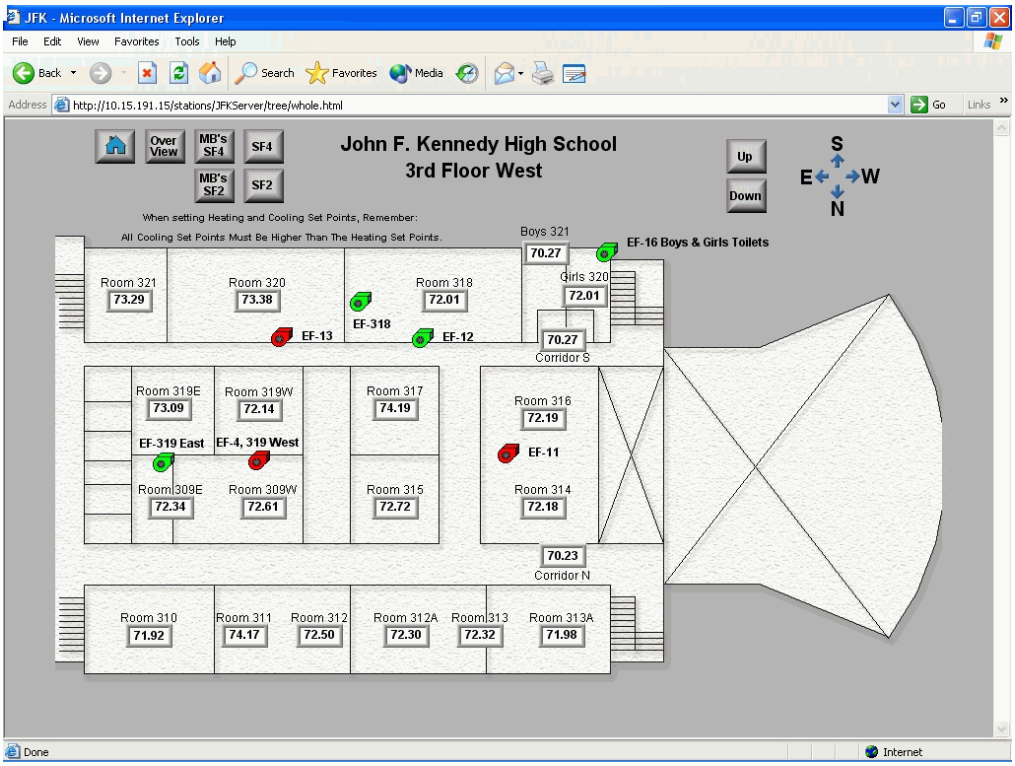

Tracer Summit - [Graphic - DePriest, DePriest]
File Connect Status View Go Setup Tools Window Help
CHICAGO PUBLIC SCHOOLS
Oscar DePriest Elementary School
139 South Parkside Ave. Chicago, Illinois 60644
Outdoor Air Temp 49.0 °
Boilers
1st Floor FPB
1st Floor
2nd Floor FPB
2nd Floor
3rd Floor
3rd Floor FPB
Chiller
Air Handler 1
Ah 1 FPB
Air Handler 2
Ah 2 FPB
Air Handler 3
Air Handlers
Air Handler 4
Ah 4 FPB
Air Handler 5
Ah 5 FPB
Hvu 1
Exhaust
Power Meter
Riser
Vav Summary

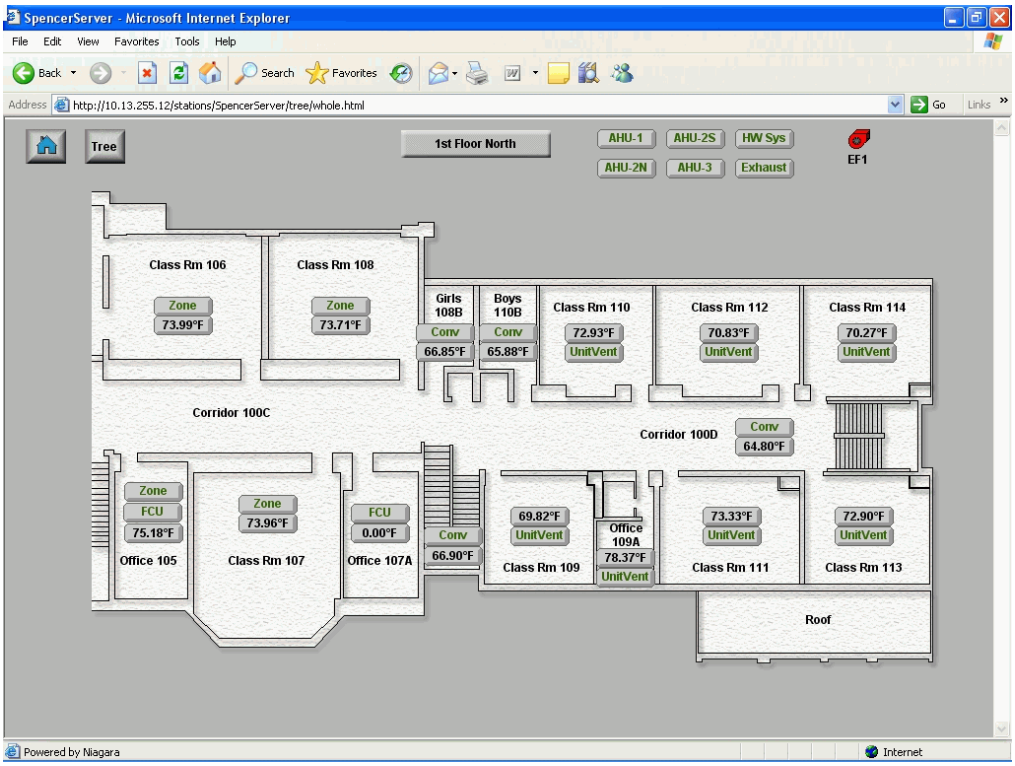
EXHIBIT B Floor Plan Example Graphics






SpencerServer - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://10.13.255.12/stations/SpencerServer/tree/whole.html
Go Links
Tree
AHU-1
AHU-2S
HW Sys
AHU-2N
AHU-3
Exhaust
Econo
Chicago Public Schools
Spencer Academy
Outdoor Air Temp / Dew Point / Humidity
37.90 °F
31.05 °F
77.19 %
Bldg Fire
Normal
Current Alarms In Bldg
View Alarm History
Clear Alarm History
3rd Floor South
3rd Floor North
Roof
2nd Floor South
2nd Floor North
Attic
1st Floor South
1st Floor North
Basement South
Basement North
Link to "/db/SpencerServer/FloorPlans/FloorPlan3South"
Internet


JFK - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://10.15.191.15/stations/JFKServer/tree/whole.html
Go Links
Over View
MB's SF4
SF4
MB's SF2
SF2
John F. Kennedy High School
3rd Floor West
Up
Down
S
E
W
N
When setting Heating and Cooling Set Points, Remember:
All Cooling Set Points Must Be Higher Than The Heating Set Points.
Boys 321
70.27
EF-16 Boys & Girls Toilets
Room 321
73.29
Room 320
73.38
Room 318
72.01
Girls 320
72.01
EF-318
EF-13
EF-12
70.27
Corridor S
Room 319E
73.09
Room 319W
72.14
Room 317
74.19
Room 316
72.19
EF-319 East
EF-4, 319 West
EF-11
Room 309E
72.34
Room 309W
72.61
Room 315
72.72
Room 314
72.18
70.23
Corridor N
Room 310
71.92
Room 311
74.17
Room 312
72.50
Room 312A
72.30
Room 313
72.32
Room 313A
71.98
Done
Internet


SpencerServer - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://10.13.255.12/stations/SpencerServer/tree/whole.html
Go Links
Tree
1st Floor North
AHU-1
AHU-2S
HW Sys
AHU-2N
AHU-3
Exhaust
EF1
Class Rm 106
Zone
73.99°F
Class Rm 108
Zone
73.71°F
Girls 108B
Conv
66.85°F
Boys 110B
Conv
65.88°F
Class Rm 110
72.93°F
UnitVent
Class Rm 112
70.83°F
UnitVent
Class Rm 114
70.27°F
UnitVent
Corridor 100C
Corridor 100D
Conv
64.80°F
Zone
FCU
75.18°F
Office 105
Zone
73.96°F
Class Rm 107
FCU
0.00°F
Office 107A
Conv
66.90°F
69.82°F
UnitVent
Class Rm 109
Office 109A
78.37°F
UnitVent
73.33°F
UnitVent
Class Rm 111
72.90°F
UnitVent
Class Rm 113
Roof
Powered by Niagara
Internet

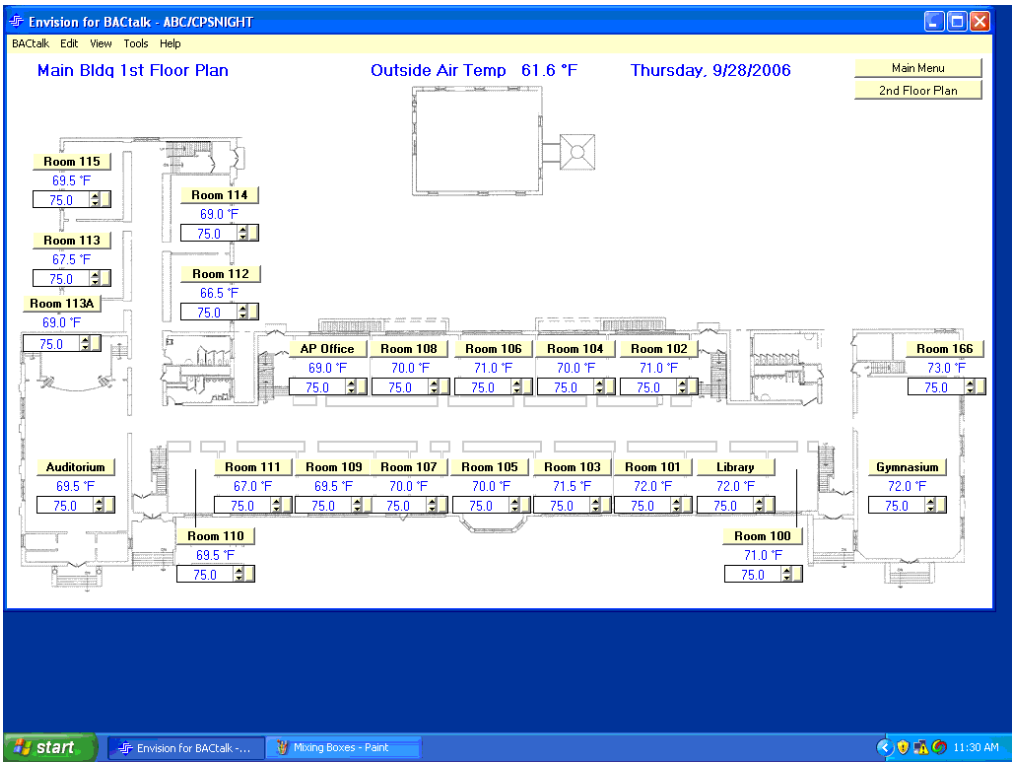
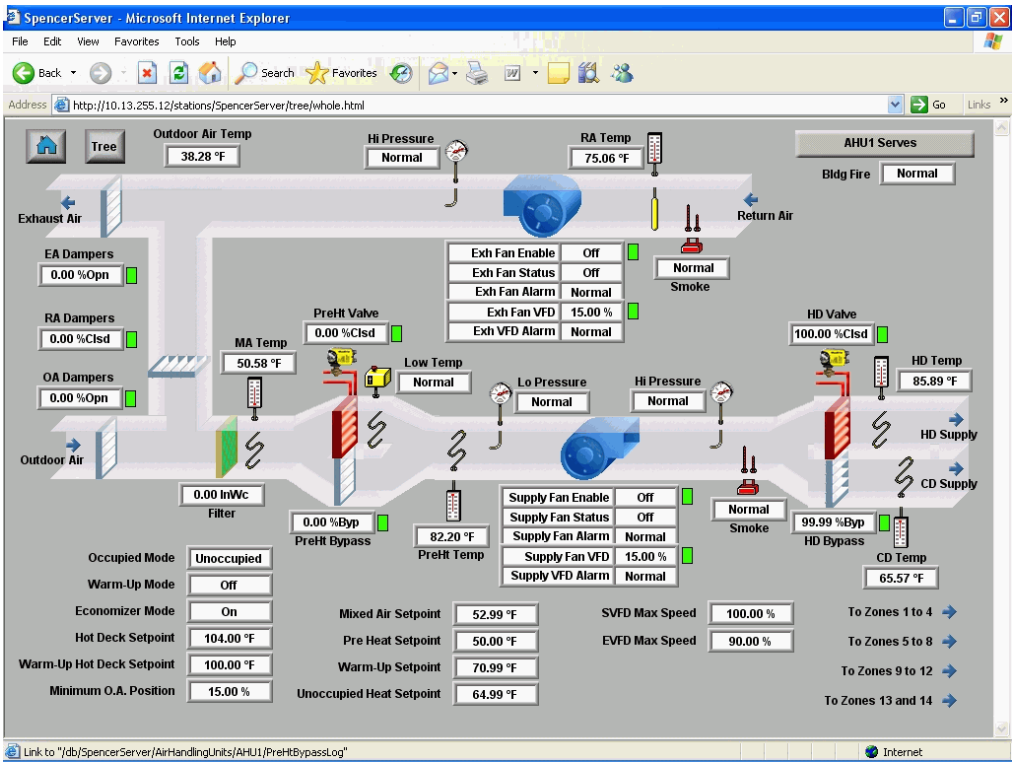
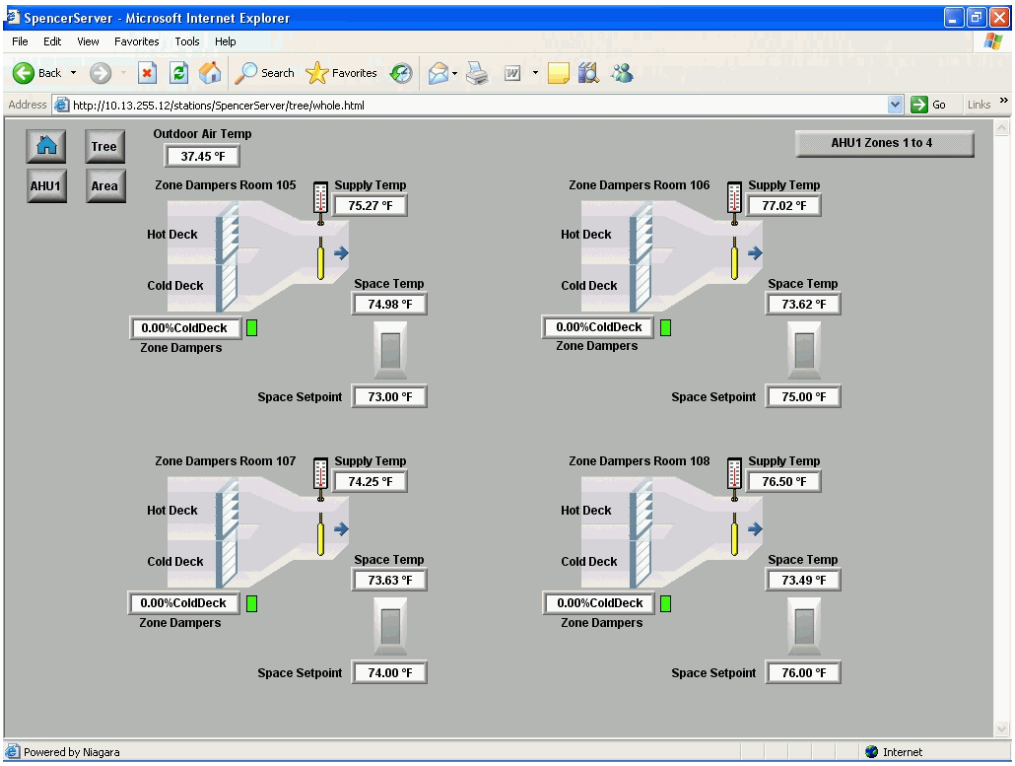
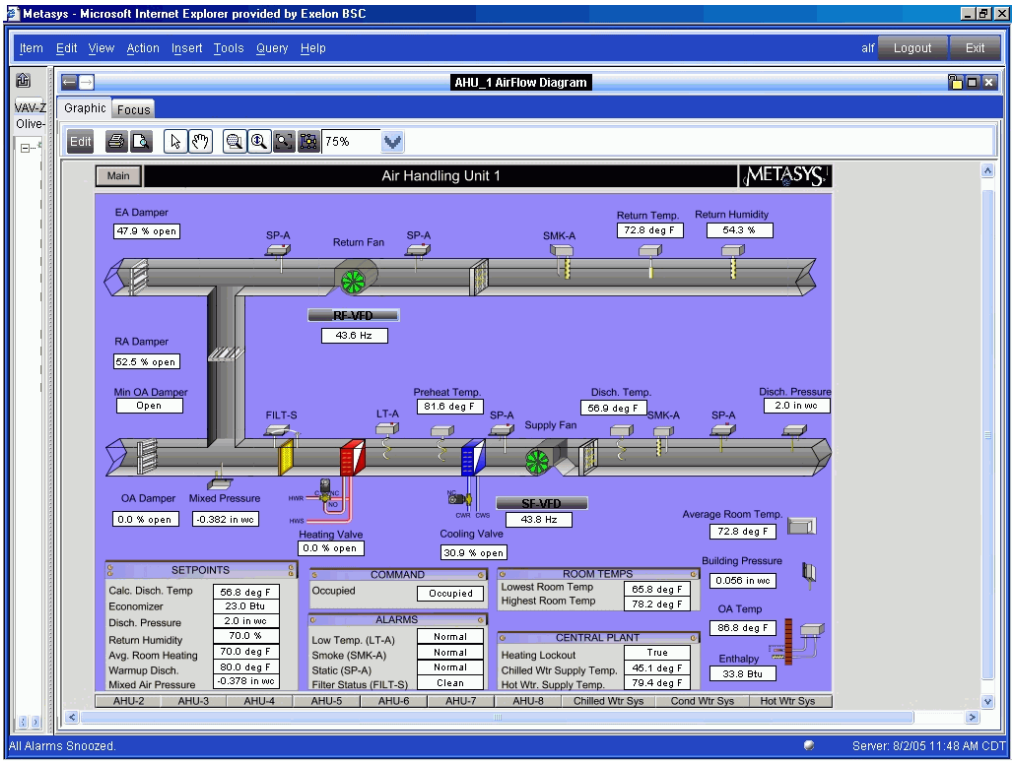
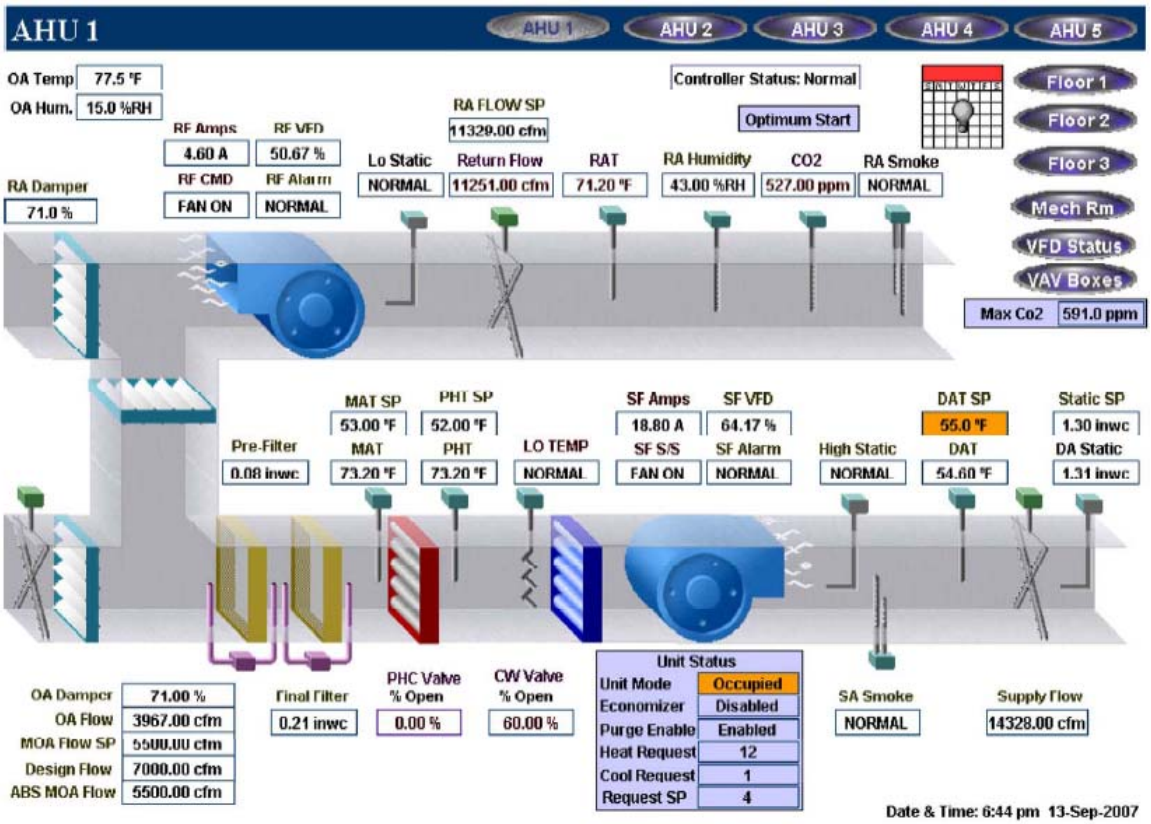

Envision for BACtalk - ABC/CPSNIGHT
BACtalk Edit View Tools Help
Main Bldg 1st Floor Plan
Outside Air Temp 61.6 °F
Thursday, 9/28/2006
Main Menu
2nd Floor Plan
Room 115
69.5 °F
75.0
Room 114
69.0 °F
75.0
Room 113
67.5 °F
75.0
Room 112
66.5 °F
75.0
Room 113A
69.0 °F
75.0
AP Office
69.0 °F
75.0
Room 108
70.0 °F
75.0
Room 106
71.0 °F
75.0
Room 104
70.0 °F
75.0
Room 102
71.0 °F
75.0
Room 166
73.0 °F
75.0
Auditorium
69.5 °F
75.0
Room 111
67.0 °F
75.0
Room 109
69.5 °F
75.0
Room 107
70.0 °F
75.0
Room 105
70.0 °F
75.0
Room 103
71.5 °F
75.0
Room 101
72.0 °F
75.0
Library
72.0 °F
75.0
Gymnasium
72.0 °F
75.0
Room 110
69.5 °F
75.0
Room 100
71.0 °F
75.0
start
Envision for BACtalk -...
Mixing Boxes - Paint
11:30 AM

EXHIBIT C System Schematic Example Graphics






Metasys - Microsoft Internet Explorer provided by Exelon BSC
Item Edit View Action Insert Tools Query Help
Logout Exit
AHU_1 AirFlow Diagram
Graphic Focus
Main
Air Handling Unit 1
METASYS
EA Damper
47.9 % open
SP-A
Return Fan
SP-A
SMK-A
Return Temp.
72.8 deg F
Return Humidity
54.3 %
RF VFD
43.8 Hz
RA Damper
52.5 % open
Min OA Damper
Open
FILT-S
LT-A
Preheat Temp.
81.6 deg F
SP-A
Supply Fan
Disch. Temp.
56.9 deg F
SMK-A
SP-A
Disch. Pressure
2.0 in wc
OA Damper
0.0 % open
Mixed Pressure
-0.382 in wc
SF VFD
43.8 Hz
Heating Valve
0.0 % open
Cooling Valve
30.9 % open
Average Room Temp.
72.8 deg F
Building Pressure
0.056 in wc
SETPOINTS
Calc. Disch. Temp 56.8 deg F
Economizer 23.0 Btu
Disch. Pressure 2.0 in wc
Return Humidity 70.0 %
Avg. Room Heating 70.0 deg F
Warmup Disch. 80.0 deg F
Mixed Air Pressure -0.378 in wc
COMMAND
Occupied Occupied
ALARMS
Low Temp. (LT-A) Normal
Smoke (SMK-A) Normal
Static (SP-A) Normal
Filter Status (FILT-S) Clean
ROOM TEMPS
Lowest Room Temp 65.8 deg F
Highest Room Temp 78.2 deg F
CENTRAL PLANT
Heating Lockout True
Chilled Wtr Supply Temp. 45.1 deg F
Hot Wtr. Supply Temp. 79.4 deg F
OA Temp
86.8 deg F
Enthalpy
33.8 Btu
AHU-2 AHU-3 AHU-4 AHU-5 AHU-6 AHU-7 AHU-8 Chilled Wtr Sys Cond Wtr Sys Hot Wtr Sys
All Alarms Snoozed.
Server: 8/2/05 11:48 AM CDT


AHU 1
AHU 1 AHU 2 AHU 3 AHU 4 AHU 5
OA Temp 77.5 °F
OA Hum. 15.0 %RH
Controller Status: Normal
Optimum Start
RA FLOW SP
11329.00 cfm
RF Amps
4.60 A
RF VFD
50.67 %
RF CMD
FAN ON
RF Alarm
NORMAL
RA Damper
71.0 %
Lo Static
NORMAL
Return Flow
11251.00 cfm
RAT
71.20 °F
RA Humidity
43.00 %RH
CO2
527.00 ppm
RA Smoke
NORMAL
Floor 1
Floor 2
Floor 3
Mech Rm
VFD Status
VAV Boxes
Max Co2 591.0 ppm
MAT SP
53.00 °F
PHT SP
52.00 °F
SF Amps
18.80 A
SF VFD
64.17 %
DAT SP
55.0 °F
Static SP
1.30 inwc
Pre-Filter
0.08 inwc
MAT
73.20 °F
PHT
73.20 °F
LO TEMP
NORMAL
SF S/S
FAN ON
SF Alarm
NORMAL
High Static
NORMAL
DAT
54.60 °F
DA Static
1.31 inwc
OA Damper 71.00 %
OA Flow 3967.00 cfm
MOA Flow SP 5500.00 cfm
Design Flow 7000.00 cfm
ABS MOA Flow 5500.00 cfm
Final Filter
0.21 inwc
PHC Valve % Open
0.00 %
CW Valve % Open
60.00 %
Unit Status
Unit Mode Occupied
Economizer Disabled
Purge Enable Enabled
Heat Request 12
Cool Request 1
Request SP 4
SA Smoke
NORMAL
Supply Flow
14328.00 cfm
Date & Time: 6:44 pm 13-Sep-2007

Additional Info pages

	SF VFD	RF VFD
Speed	64.17 %	50.67 %
Frequency	30.40 hz	29.00 hz
RPM	1135.00 rpm	887.00 rpm
Voltage	295.00 V	176.00 V
Run Hours	1636.00 hrs	1602.00 hrs
Power	6.30 kW	0.70 kW
Current	18.80 A	4.60 A
Fault	Normal	Normal
Running Status	Running	Running

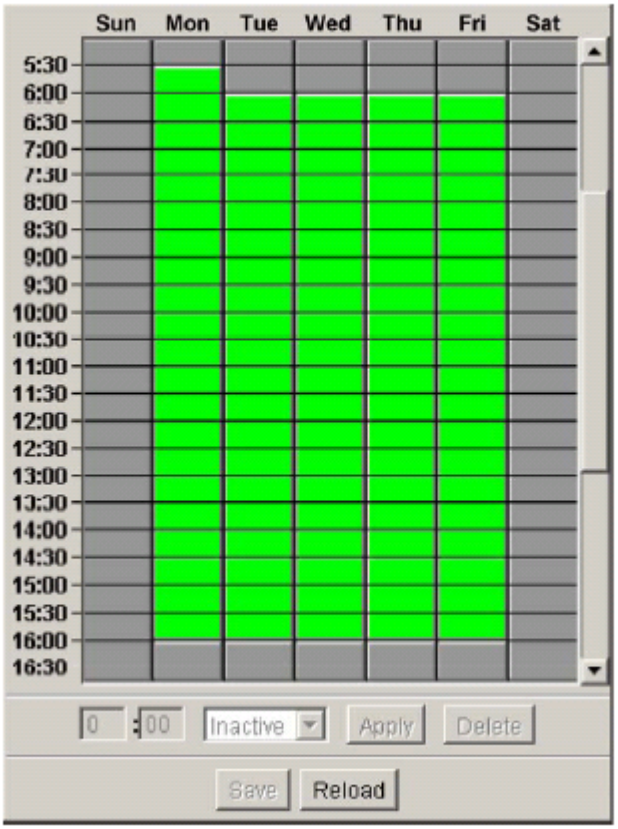
Cool Down Setpoint	74.00
Warm Up Setpoint	73.00
Selected Rm Temp	73.90
Oa Change Over	65.00
Max Space Temp	73.90
Min Space Temp	64.50

Optimal Start Status

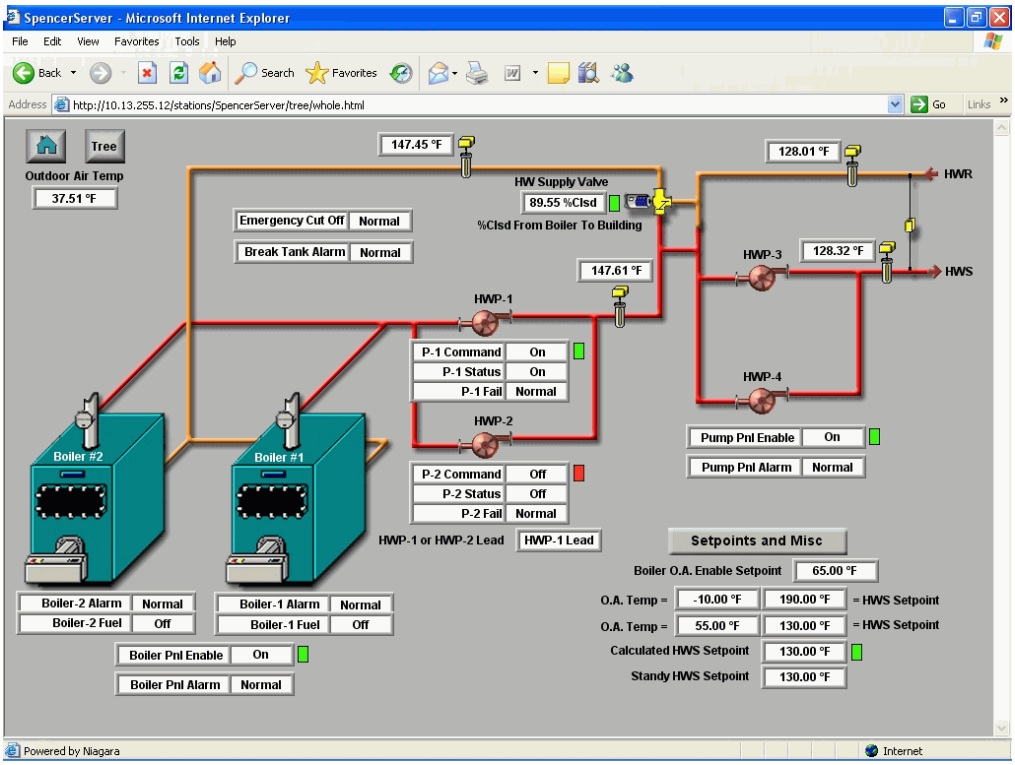
Scheduled Start: 6:00am 14-Sep-2007

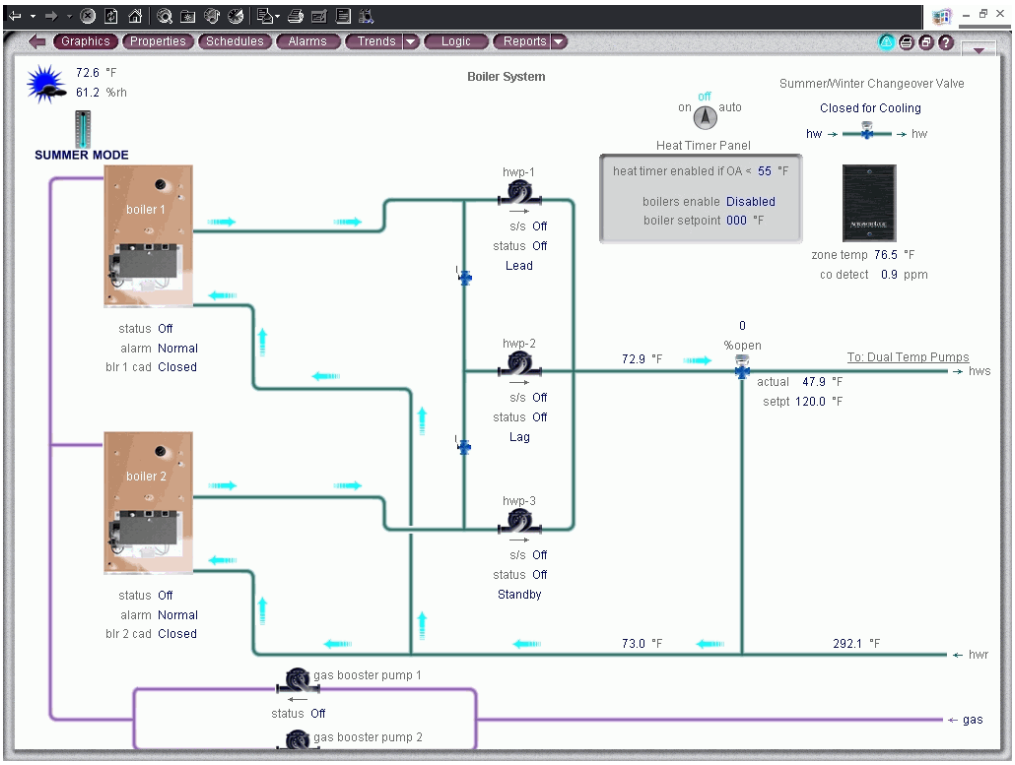
Schedule

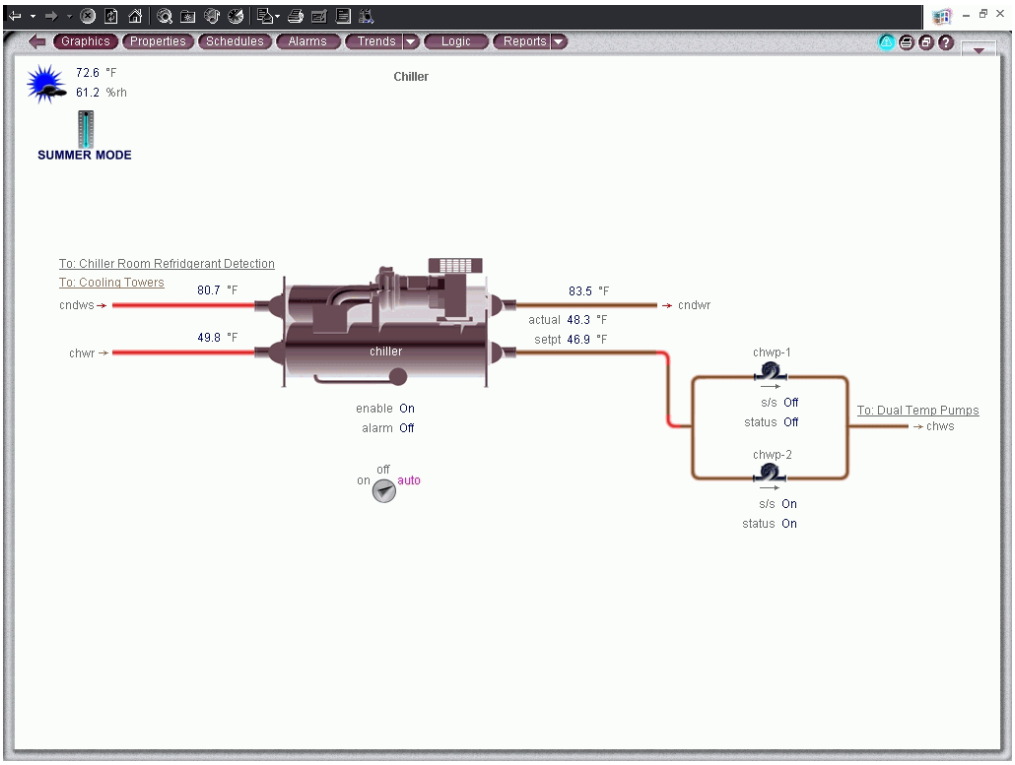
Weekly Schedule: /Albany_Park/Albany/AHU_1/Schedule

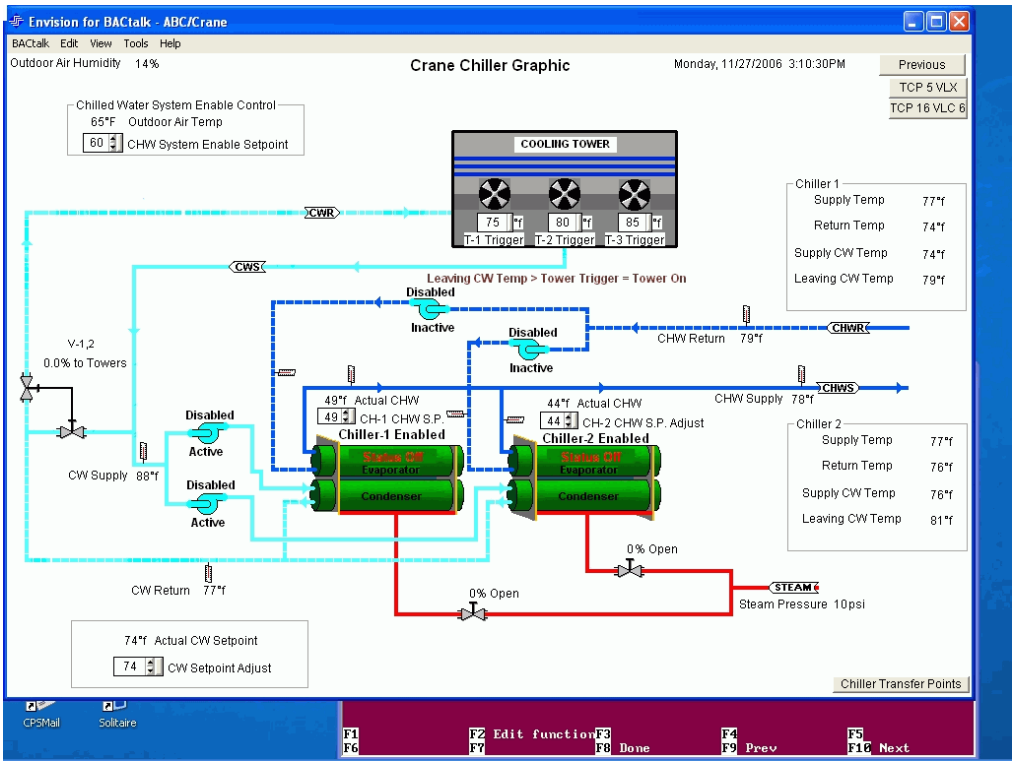


Summary Weekly Holiday Special Events Calendar


SpencerServer - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://10.13.255.12/stations/SpencerServer/tree/whole.html
Go Links
Tree
Outdoor Air Temp
37.51 °F
147.45 °F
HW Supply Valve
89.55 %Clsd
%Clsd From Boiler To Building
Emergency Cut Off Normal
Break Tank Alarm Normal
147.61 °F
128.01 °F
HWR
HWP-3
128.32 °F
HWS
HWP-1
P-1 Command On
P-1 Status On
P-1 Fail Normal
HWP-4
HWP-2
P-2 Command Off
P-2 Status Off
P-2 Fail Normal
Pump Pnl Enable On
Pump Pnl Alarm Normal
Boiler #2
Boiler #1
HWP-1 or HWP-2 Lead
HWP-1 Lead
Setpoints and Misc
Boiler O.A. Enable Setpoint 65.00 °F
Boiler-2 Alarm Normal
Boiler-2 Fuel Off
Boiler-1 Alarm Normal
Boiler-1 Fuel Off
O.A. Temp = -10.00 °F 190.00 °F = HWS Setpoint
O.A. Temp = 55.00 °F 130.00 °F = HWS Setpoint
Calculated HWS Setpoint 130.00 °F
Standy HWS Setpoint 130.00 °F
Boiler Pnl Enable On
Boiler Pnl Alarm Normal
Powered by Niagara
Internet


Graphics Properties Schedules Alarms Trends Logic Reports
72.6 °F
61.2 %rh
SUMMER MODE
Boiler System
Summer/Winter Changeover Valve
off
on auto
Closed for Cooling
hw hw
Heat Timer Panel
heat timer enabled if OA < 55 °F
boilers enable Disabled
boiler setpoint 000 °F
zone temp 76.5 °F
co detect 0.9 ppm
boiler 1
status Off
alarm Normal
blr 1 cad Closed
hwp-1
s/s Off
status Off
Lead
hwp-2
s/s Off
status Off
Lag
0
%open
72.9 °F
To: Dual Temp Pumps
hws
actual 47.9 °F
setpt 120.0 °F
boiler 2
status Off
alarm Normal
blr 2 cad Closed
hwp-3
s/s Off
status Off
Standby
73.0 °F
292.1 °F
hwr
gas booster pump 1
status Off
gas booster pump 2
gas


Graphics
Properties
Schedules
Alarms
Trends
Logic
Reports
Chiller
72.6 °F
61.2 %rh
SUMMER MODE
To: Chiller Room Refridgerant Detection
To: Cooling Towers
cndws
80.7 °F
chwr
49.8 °F
chiller
83.5 °F
cndwr
actual 48.3 °F
setpt 46.9 °F
enable On
alarm Off
off
on
auto
chwp-1
s/s Off
status Off
chwp-2
s/s On
status On
To: Dual Temp Pumps
chws


Envision for BACtalk - ABC/Crane
BACtalk Edit View Tools Help
Outdoor Air Humidity 14%
Crane Chiller Graphic
Monday, 11/27/2006 3:10:30PM
Previous
TCP 5 VLX
TCP 16 VLC 6
Chilled Water System Enable Control
65°F Outdoor Air Temp
60 CHW System Enable Setpoint
COOLING TOWER
75 °f T-1 Trigger
80 °f T-2 Trigger
85 °f T-3 Trigger
CWR
CWS
Leaving CW Temp > Tower Trigger = Tower On
Disabled
Inactive
Disabled
Inactive
CHW Return 79°f
CHWR
V-1,2
0.0% to Towers
CW Supply 88°f
Disabled
Active
Disabled
Active
49°f Actual CHW
49 CH-1 CHW S.P.
Chiller-1 Enabled
Status Off
Evaporator
Condenser
44°f Actual CHW
44 CH-2 CHW S.P. Adjust
Chiller-2 Enabled
Status Off
Evaporator
Condenser
CHW Supply 78°f
CHWS
Chiller 1
Supply Temp 77°f
Return Temp 74°f
Supply CW Temp 74°f
Leaving CW Temp 79°f
Chiller 2
Supply Temp 77°f
Return Temp 76°f
Supply CW Temp 76°f
Leaving CW Temp 81°f
0% Open
CW Return 77°f
0% Open
STEAM
Steam Pressure 10psi
74°f Actual CW Setpoint
74 CW Setpoint Adjust
Chiller Transfer Points
CPSMail
Solitaire
F1 F6
F2 Edit function F7
F3 F8 Done
F4 F9 Prev
F5 F10 Next

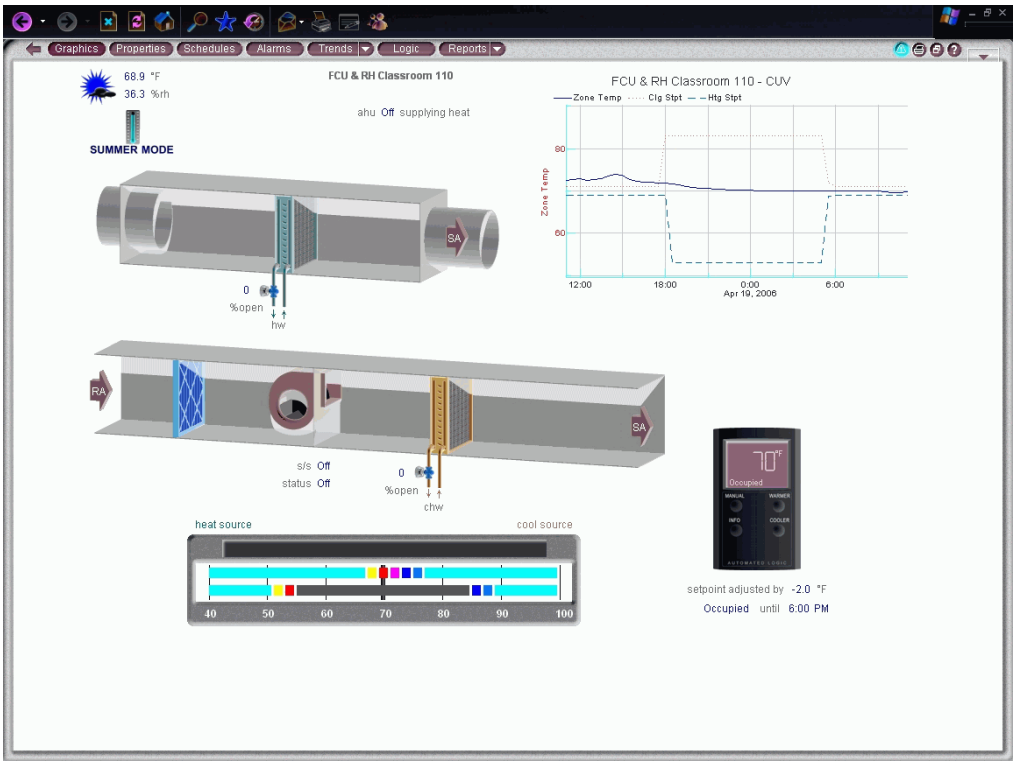
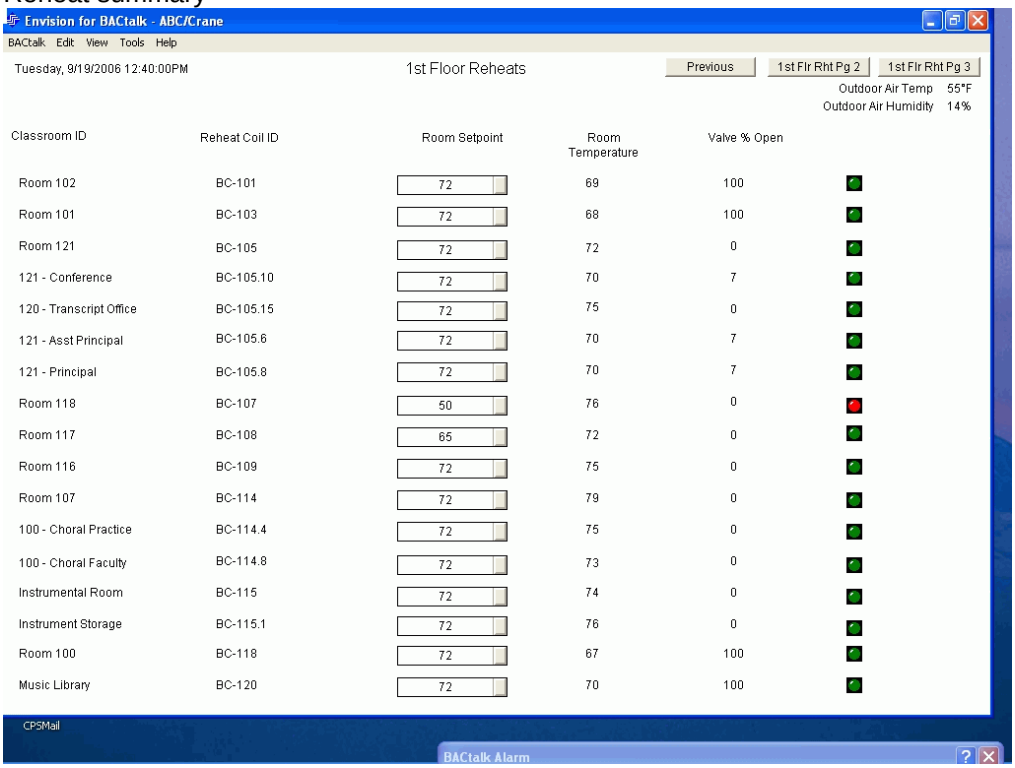
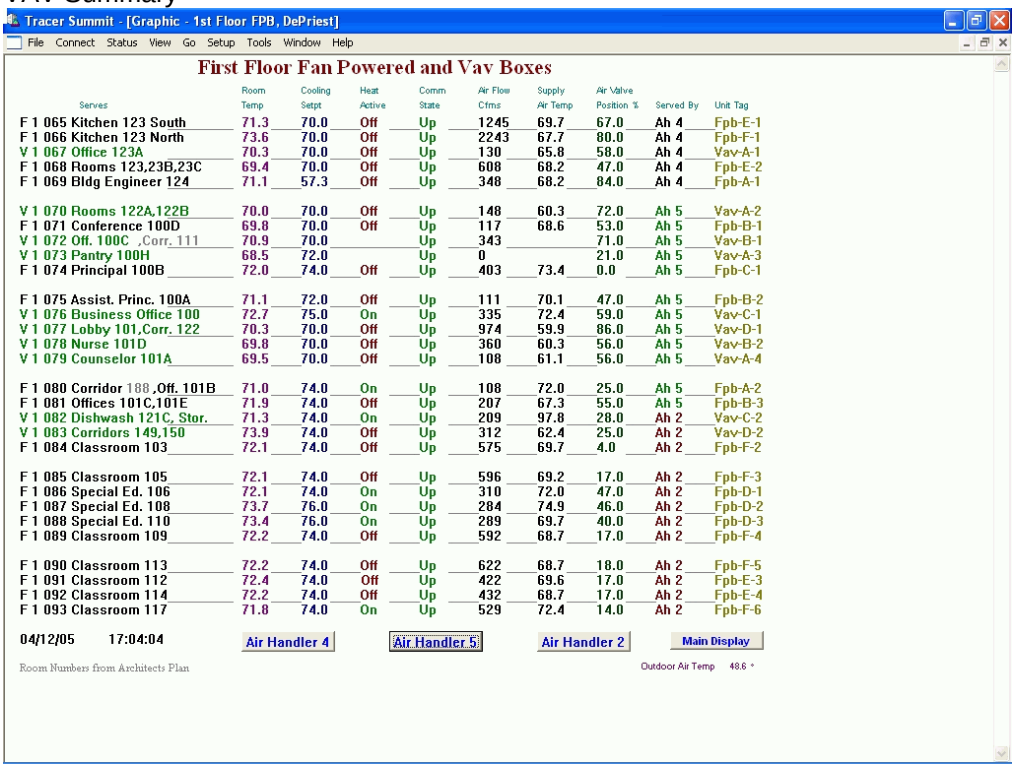

Graphics
Properties
Schedules
Alarms
Trends
Logic
Reports
68.9 °F
36.3 %rh
SUMMER MODE
FCU & RH Classroom 110
ahu Off supplying heat
FCU & RH Classroom 110 - CUV
Zone Temp
Clg Stpt
Htg Stpt
Zone Temp
80
60
12:00
18:00
0:00
Apr 19, 2006
6:00
SA
0
%open
hw
RA
SA
s/s Off
status Off
0
%open
chw
heat source
cool source
40
50
60
70
80
90
100
70°F
Occupied
setpoint adjusted by -2.0 °F
Occupied until 6:00 PM

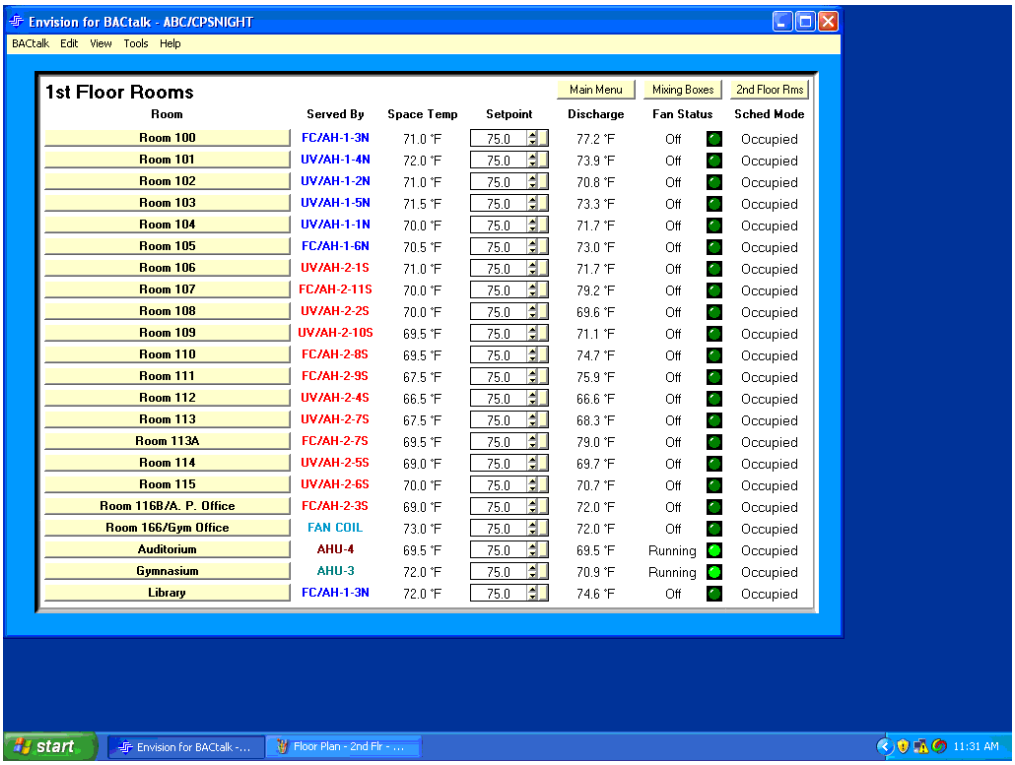
EXHIBIT D System Summary Example Graphics

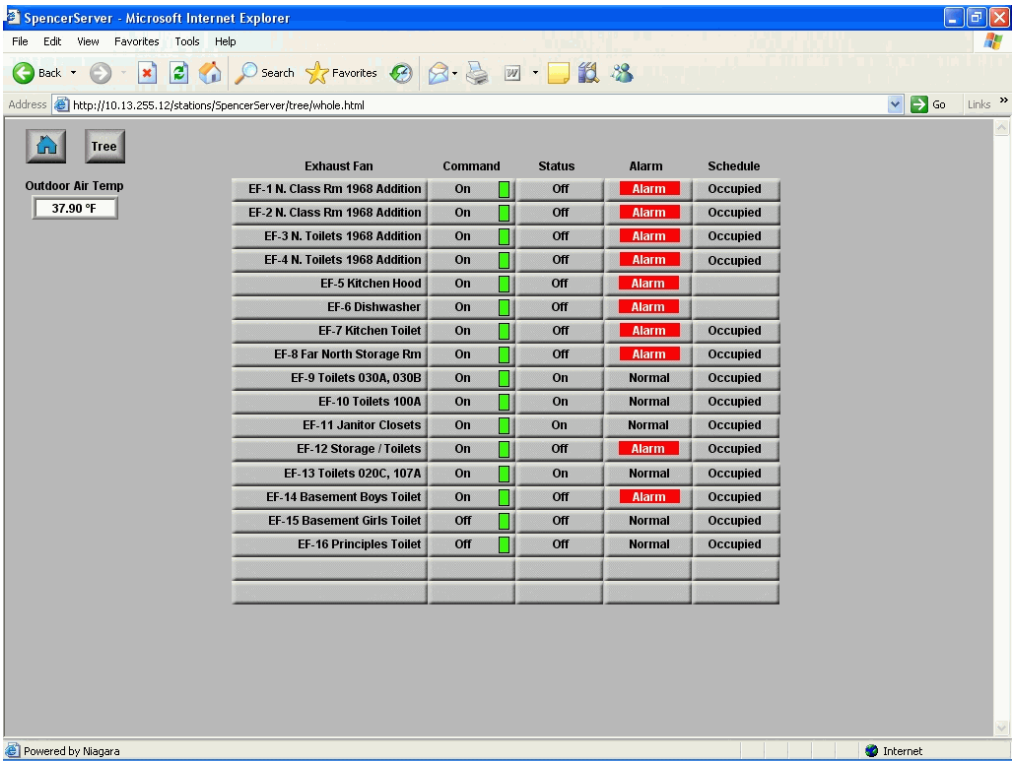
Reheat summary



VAV Summary

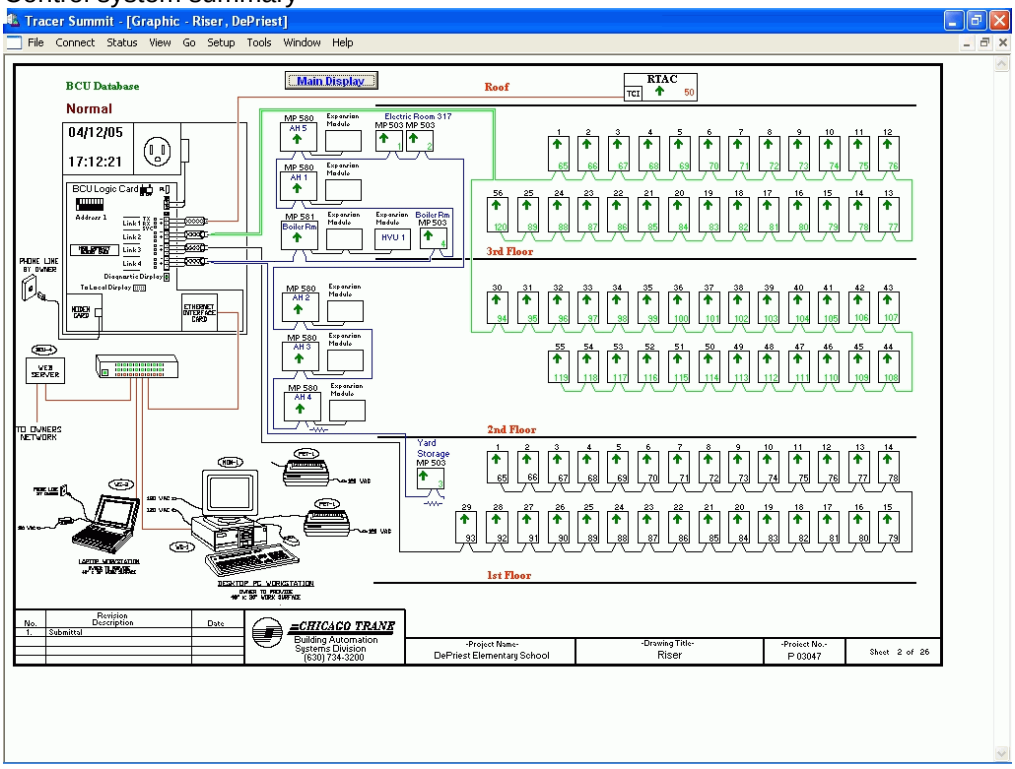



Envision for BACtalk - ABC/CPSNIGHT
BACtalk Edit View Tools Help
1st Floor Rooms
Main Menu
Mixing Boxes
2nd Floor Rms
Room | Served By | Space Temp | Setpoint | Discharge | Fan Status | Sched Mode
Room 100 | FC/AH-1-3N | 71.0 °F | 75.0 | 77.2 °F | Off | Occupied
Room 101 | UV/AH-1-4N | 72.0 °F | 75.0 | 73.9 °F | Off | Occupied
Room 102 | UV/AH-1-2N | 71.0 °F | 75.0 | 70.8 °F | Off | Occupied
Room 103 | UV/AH-1-5N | 71.5 °F | 75.0 | 73.3 °F | Off | Occupied
Room 104 | UV/AH-1-1N | 70.0 °F | 75.0 | 71.7 °F | Off | Occupied
Room 105 | FC/AH-1-6N | 70.5 °F | 75.0 | 73.0 °F | Off | Occupied
Room 106 | UV/AH-2-1S | 71.0 °F | 75.0 | 71.7 °F | Off | Occupied
Room 107 | FC/AH-2-11S | 70.0 °F | 75.0 | 79.2 °F | Off | Occupied
Room 108 | UV/AH-2-2S | 70.0 °F | 75.0 | 69.6 °F | Off | Occupied
Room 109 | UV/AH-2-10S | 69.5 °F | 75.0 | 71.1 °F | Off | Occupied
Room 110 | FC/AH-2-8S | 69.5 °F | 75.0 | 74.7 °F | Off | Occupied
Room 111 | FC/AH-2-9S | 67.5 °F | 75.0 | 75.9 °F | Off | Occupied
Room 112 | UV/AH-2-4S | 66.5 °F | 75.0 | 66.6 °F | Off | Occupied
Room 113 | UV/AH-2-7S | 67.5 °F | 75.0 | 68.3 °F | Off | Occupied
Room 113A | FC/AH-2-7S | 69.5 °F | 75.0 | 79.0 °F | Off | Occupied
Room 114 | UV/AH-2-5S | 69.0 °F | 75.0 | 69.7 °F | Off | Occupied
Room 115 | UV/AH-2-6S | 70.0 °F | 75.0 | 70.7 °F | Off | Occupied
Room 116B/A. P. Office | FC/AH-2-3S | 69.0 °F | 75.0 | 72.0 °F | Off | Occupied
Room 166/Gym Office | FAN COIL | 73.0 °F | 75.0 | 72.0 °F | Off | Occupied
Auditorium | AHU-4 | 69.5 °F | 75.0 | 69.5 °F | Running | Occupied
Gymnasium | AHU-3 | 72.0 °F | 75.0 | 70.9 °F | Running | Occupied
Library | FC/AH-1-3N | 72.0 °F | 75.0 | 74.6 °F | Off | Occupied
start
Envision for BACtalk -...
Floor Plan - 2nd Flr - ...
11:31 AM

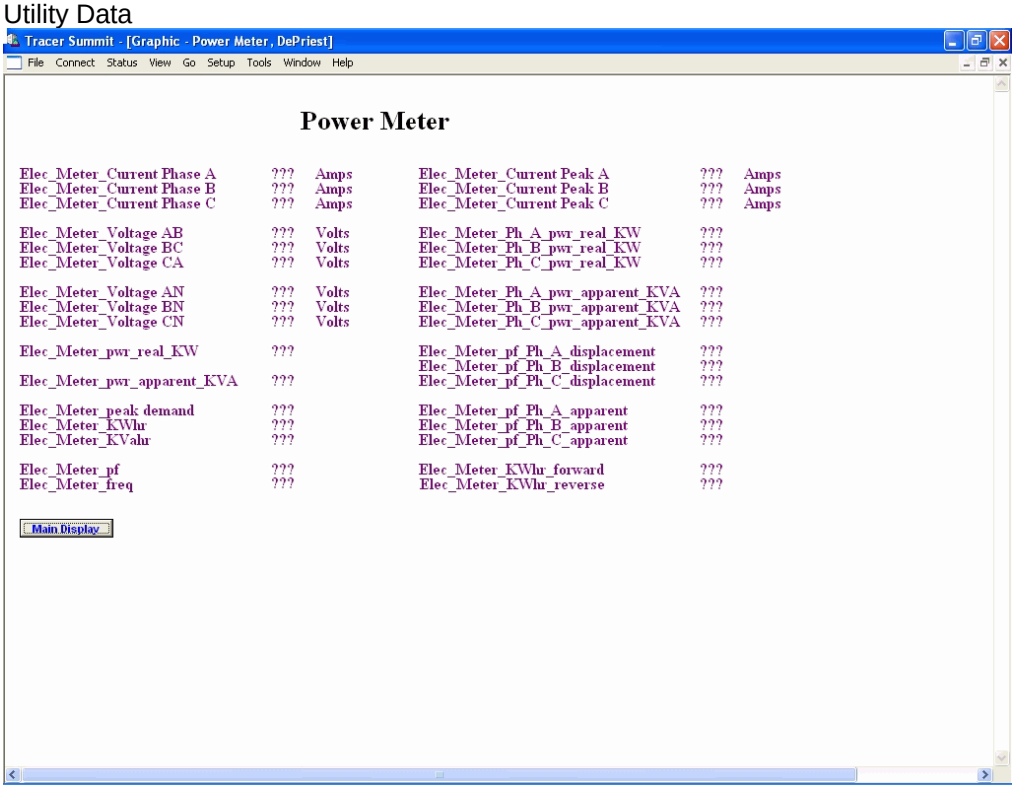

SpencerServer - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://10.13.255.12/stations/SpencerServer/tree/whole.html
Go Links
Tree
Outdoor Air Temp
37.90 °F
Exhaust Fan | Command | Status | Alarm | Schedule
EF-1 N. Class Rm 1968 Addition | On | Off | Alarm | Occupied
EF-2 N. Class Rm 1968 Addition | On | Off | Alarm | Occupied
EF-3 N. Toilets 1968 Addition | On | Off | Alarm | Occupied
EF-4 N. Toilets 1968 Addition | On | Off | Alarm | Occupied
EF-5 Kitchen Hood | On | Off | Alarm |
EF-6 Dishwasher | On | Off | Alarm |
EF-7 Kitchen Toilet | On | Off | Alarm | Occupied
EF-8 Far North Storage Rm | On | Off | Alarm | Occupied
EF-9 Toilets 030A, 030B | On | On | Normal | Occupied
EF-10 Toilets 100A | On | On | Normal | Occupied
EF-11 Janitor Closets | On | On | Normal | Occupied
EF-12 Storage / Toilets | On | Off | Alarm | Occupied
EF-13 Toilets 020C, 107A | On | On | Normal | Occupied
EF-14 Basement Boys Toilet | On | Off | Alarm | Occupied
EF-15 Basement Girls Toilet | Off | Off | Normal | Occupied
EF-16 Principles Toilet | Off | Off | Normal | Occupied
Powered by Niagara
Internet

Fan Summary

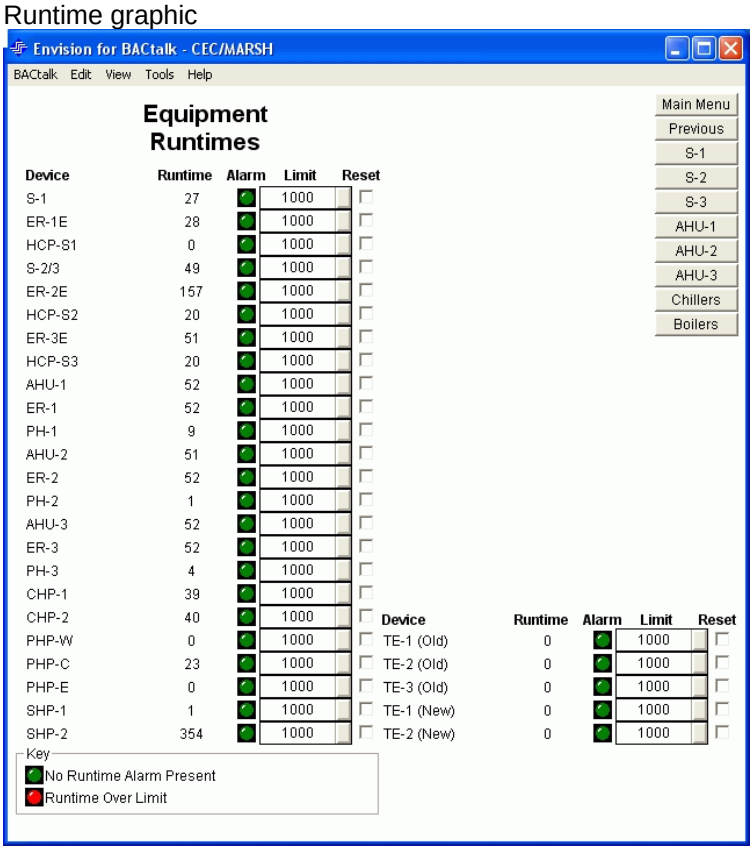
Control system summary



Utility Data



Runtime graphic



NATURAL GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:
1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Joining materials for piping and tubing.
4. Valves.
5. Pressure regulators.
6. Service meters.
7. Mechanical sleeve seals.
8. Booster pumps.
9. Concrete bases.
10. Grout.

1.2 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roofs, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Anodless Risers and Sweeps: Fittings that can be installed without additional cathodic protection.

1.3 PERFORMANCE REQUIREMENTS

A. Natural-Gas System Pressure within Buildings: 2-psig or less.

B. Operating Pressure Ratings:
1. Piping and Valves: 100-psig minimum unless otherwise indicated.
2. Service Regulators: 65-psig minimum unless otherwise indicated.
3. Operating Pressure of Service Meter: 5-psig minimum unless otherwise indicated.

1.4 SUBMITTALS

A. Product Data: For each type of the following:
1. Piping specialties.
2. Corrugated, stainless-steel tubing with associated components.
3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.
5. Dielectric fittings.
6. Mechanical sleeve seals.
7. Escutcheons.
8. Packaged Gas Boosters: Include certified performance curves with operating points plotted; rated capacities of selected models; and furnished specialties and accessories. Include information on the following:
a. Piping.
b. Flexible connectors.
c. Plug valves.
d. Inlet check valve.
e. Pressure gauge.
f. Pressure switch.
g. Recirculation loop and valve.
h. Heat exchanger.
i. Control panel.

B. Shop Drawings: Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail locations of anchors, alignment guides, and

expansion joints and loops. Include a site plan, on which natural-gas piping is indicated and coordinated with other services and utilities.

1. Shop Drawing Scale: Not less than 1/4" = 1'-0".
2. Packaged Gas Boosters: Provide detailed shop drawings for packaged gas boosters and accessories. Include plans, elevations, sections, details, and attachment to other work; power, signal, and control wiring diagrams; dimensioned outline drawings of equipment package, identifying center of gravity and including detailed mounting and anchorage provisions; vibration isolation, including detailed fabrication information, attachments to concrete slabs and supported equipment; operation and maintenance data, including emergency, standard operation and maintenance manuals.

C. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

D. Installer Qualifications.

E. Welding Certificates.

F. Reports:

1. Field quality-control reports.
2. Startup Reports: Submit reports documenting activities required during startup of gas boosters. Reports shall be submitted within two weeks following completion of startup activities.
3. Training Reports: Submit reports regarding training of Owner's maintenance personnel. Include date(s) of training and list of attendees.

G. Operation and Maintenance Data: For motorized gas valves, pressure regulators, and service meters, include data in emergency, operation, and maintenance manuals.

H. Record Drawings: Indicate, at 1/4" = 1'-0" scale, the actual natural-gas piping installation layout and elevations, sections, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Engage an installer that is experienced in the installation of natural-gas piping of the types required for the Project, and whose work has resulted in a record of successful in-service performance.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of packaged gas boosters and are based on the specific system indicated.

C. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Packaged Gas Boosters: Installed according to the National Electrical Code (NFPA 70) and the National Fuel Gas Code (NFPA 54).

G. Regulatory Requirements: Natural-gas piping installations shall comply with the International Fuel Gas Code, 2000 edition.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose flammable liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps throughout shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored polyethylene pipes and valves from direct sunlight.

E. Gas Boosters: Retain gas booster shipping flange protective covers and coatings, protect bearings and couplings against damage, and comply with manufacturer's written rigging instructions when handling packaged gas boosters.

1.7 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
   1. Notify Owner no fewer than seven days in advance of proposed interruption of natural-gas service.
   2. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate installation of anchorages for natural-gas systems. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete. Deliver such items to Project site in time for installation and to not cause a delay in the Work.

C. Coordinate requirements for access panels and doors for valves and controls installed concealed behind finished surfaces, and for areas requiring routine maintenance. Comply with requirements in Division 08 Section "Access Doors and Frames."

1.9 WARRANTY

A. Special Warranty: Submit written warranty, executed by the manufacturer and Installer, agreeing to repair or replace components that develop defects in material or workmanship within the specified warranty period.
   1. Warranty Period for Natural-Gas Systems: One year from date of Substantial Completion, or eighteen months from date of shipment, whichever is greater.
   2. Warranty Period for Controls and Control Panels: Three years from dated of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the manufacturers indicated for each component:
   1. Appliance Flexible Connector: No preference.
   2. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
      a. Conbraco Industries, Inc.; Apollo Div.
      b. Lyall, R. W. and Company, Inc.
      c. McDonald, A. Y. Mfg. Co.
      d. Perfection Corporation; a subsidiary of American Meter Company.
   3. Bronze Plug Valves:
      a. Lee Brass Company.
      b. McDonald, A. Y. Mfg. Co.
   4. Cast-Iron, Non-lubricated Plug Valves:
      a. McDonald, A. Y. Mfg. Co.
      b. Mueller Co.; Gas Products Div.
      c. Xomox Corporation; a Crane company.
   5. Cast-Iron, Lubricated Plug Valves:
      a. Flowserve.
      b. McDonald, A. Y. Mfg. Co.
      c. Mueller Co.; Gas Products Div.
      d. RandM Energy Systems, a Unit of Robbins and Myers, Inc.
   6. Automatic Gas Valves:
      a. ASCO Power Technologies, LP; Division of Emerson.
      b. Eaton Corporation; Controls Div.
      c. Eclipse Combustion, Inc.

d. Honeywell International Inc.
e. Johnson Controls.

7. Electrically Operated Valves:
   a. ASCO Power Technologies, LP; Division of Emerson.
   b. Eclipse Combustion, Inc.
   c. Goyen Valve Corp.; Tyco Environmental Systems.
   d. Magnatrol Valve Corporation.
   e. Parker Hannifin Corporation; Climate and Industrial Controls Group; Skinner Valve Div.
   f. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
8. Line Pressure Regulators:
   a. Eclipse Combustion, Inc.
   b. Fisher Control Valves and Regulators; Division of Emerson Process Management.
   c. Invensys.
   d. Maxitrol Company.
   e. Richards Industries; Jordan Valve Div.
9. Appliance Pressure Regulators:
   a. Eaton Corporation; Controls Div.
   b. Harper Wyman Co.
   c. Maxitrol Company.
   d. SCP, Inc.
10. Dielectric Unions: No preference.
11. Dielectric Flanges: No preference.
12. Mechanical Sleeves: No preference.

2.2 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.
   1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
   2. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.
   3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
   4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
      a. Material Group: 1.1.
      b. End Connections: Threaded or butt welding to match pipe.
      c. Lapped Face: Not permitted underground.
      d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
      e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

B. Polyethylene (PE) Pipe: ASTM D2513, SDR 11 (Underground Piping Only).
   1. PE Fittings: ASTM D2683, socket-fusion type or ASTM D3261, butt-fusion type with dimensions matching PE pipe.
   2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D2513, SDR 11; and steel pipe complying with ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.
   3. Anodeless Service-Line Risers: Factory fabricated and leak tested.
      a. Underground Portion: PE pipe complying with ASTM D2513, SDR 11 inlet. Underground piping to receive factory-applied, three layer coating of epoxy, adhesive, and polyethylene.
      b. Casing: Steel pipe complying with ASTM A53/A53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground.
      c. Aboveground Portion: PE transition fitting.
      d. Outlet shall be threaded or flanged or suitable for welded connection.
      e. Tracer wire connection.
      f. Ultraviolet shield.
      g. Stake supports with factory finish to match steel pipe casing or carrier pipe.
      h. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink polyethylene sleeves.
   4. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive and polyethylene.

2.3 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.0.5-psig End Fittings: Zinc-coated steel.
6. Threaded Ends: Comply with ASME B1.20.1.
7. Maximum Length: 72-inches.

B. Y-Pattern Strainers:
1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 50-percent free area.
4. CWP Rating: 125-psig.

C. Basket Strainers:
1. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125-psig.

D. T-Pattern Strainers:
1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 57-percent free area.
4. CWP Rating: 750-psig.

E. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.4 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural-gas pipe.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 MANUAL GAS SHUTOFF VALVES

A. Refer to Articles "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
1. CWP Rating: 125-psig.
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in Articles "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule."
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch diameter and smaller.
6. Service Mark: Valves NPS 1-1/4 to NPS 2 shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
1. CWP Rating: 125-psig.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves indicated in Articles "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule."
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Two-Piece, Full-Port, Bronze Body: Complying with ASTM B584.
1. Ball: Chrome-plated bronze.
2. Stem: Bronze; blowout proof.
3. Seats: Reinforced TFE; blowout proof.

4. Packing: Threaded-body packnut design with adjustable-stem packing.
5. Ends: Threaded, flared, or socket as indicated in Articles "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule."
6. CWP Rating: 600-psig.
7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.
1. Body: Bronze, complying with ASTM B584.
2. Plug: Bronze.
3. Ends: Threaded, socket, or flanged as indicated in Articles "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule."
4. Operator: Square head or lug type with tamperproof feature where indicated.
5. Pressure Class: 125-psig.
6. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
7. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Cast-Iron, Non-lubricated Plug Valves: MSS SP-78.
1. Body: Cast iron, complying with ASTM A126, Class B.
2. Plug: Bronze or nickel-plated cast iron.
3. Seat: Coated with thermoplastic.
4. Stem Seal: Compatible with natural-gas.
5. Ends: Threaded or flanged as indicated in Articles "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule."
6. Operator: Square head or lug type with tamperproof feature where indicated.
7. Pressure Class: 125-psig.
8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. Cast-Iron, Lubricated Plug Valves: MSS SP-78.
1. Body: Cast iron, complying with ASTM A126, Class B.
2. Plug: Bronze or nickel-plated cast iron.
3. Seat: Coated with thermoplastic.
4. Stem Seal: Compatible with natural-gas.
5. Ends: Threaded or flanged as indicated in Articles "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule."
6. Operator: Square head or lug type with tamperproof feature where indicated.
7. Pressure Class: 125- psig.
8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

H. Valve Boxes:
1. Cast-iron, two-section box.
2. Top section with embossed cover with letters "GAS".
3. Bottom section with base to fit over valve and a minimum 5-inches diameter barrel.
4. Adjustable cast-iron extensions of length required for depth of embedment.
5. Include tee-handle, steel operating wrench with socket end fitting, either valve nut or flat head, with stem of length required to operate valve.

2.6 MOTORIZED GAS VALVES

A. Automatic Gas Valves: Comply with ANSI Z21.21.
1. Body: Brass or aluminum.
2. Seats and Disc: Nitrile rubber.
3. Springs and Valve Trim: Stainless steel.
4. Normally closed.
5. Visual position indicator.
6. Electrical operator for actuation by appliance automatic shutoff device.

B. Electrically Operated Valves: Comply with UL 429.
1. Pilot operated.
2. Body: Brass or aluminum.
3. Seats and Disc: Nitrile rubber.
4. Springs and Valve Trim: Stainless steel.
5. 120-V ac, 60-Hz, Class B, continuous-duty molded coil, and replaceable.
6. NEMA ICS 6, Type 4, coil enclosure.
7. Normally closed.
8. Visual position indicator.

2.7 PRESSURE REGULATORS

A. General Requirements:
1. Single stage and suitable for natural-gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Line Pressure Regulators: Comply with ANSI Z21.80.
1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
3. Diaphragm Plate: Zinc-plated steel.
4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
5. Orifice: Aluminum; interchangeable.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 1.5 times the design discharge pressure at shutoff.
9. Overpressure Protection Device: Factory mounted on pressure regulator.
10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
11. Maximum Inlet Pressure: 2-psig.

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.
1. Body and Diaphragm Case: Die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
3. Diaphragm Plate: Zinc-plated steel.
4. Seat Disc: Nitrile rubber.
5. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
6. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
7. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
8. Maximum Inlet Pressure: 2-psig

2.8 DIELECTRIC FITTINGS

A. Dielectric Unions:
1. Minimum Operating-Pressure Rating: 150-psig.
2. Combination fitting of copper alloy and ferrous materials.
3. Insulating materials suitable for natural-gas.
4. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
5. Dielectric Flanges:
6. Minimum Operating-Pressure Rating: 150-psig
7. Combination fitting of copper alloy and ferrous materials.
8. Insulating materials suitable for natural-gas.
9. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

2.9 SLEEVES

A. Steel Pipe Sleeves: ASTM A53, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

2.10 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   1. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
   2. Pressure Plates: Stainless steel.
   3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.

2.11 ESCUTCHEONS

A. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube, and OD that completely covers opening.

B. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Stamped-Steel Escutcheons: With set screw and chrome-plated finish.

D. Split-Plate, Stamped-Steel Escutcheons: With concealed hinge, set screw, and chrome-plated finish.

E. One-Piece, Floor-Plate Escutcheons: Cast-iron floor plate.

F. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

2.12 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6-inches wide and 4-mils thick, continuously inscribed with a description of utility and the word "CAUTION", and colored yellow.

B. Safety Tracer Wire: Metallic core (copper minimum AWG 14) encased in a protective insulated jacket for corrosion protection, detectable by metal detector when tape is buried up to 36-inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural-gas to premises or piping section.

B. Inspect natural gas piping according to the International Fuel Gas Code to determine that natural gas utilization devices are turned off in piping section(s) affected.

C. Comply with the International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Underground Installations: Install underground natural-gas piping according to ASTM D2774.
   1. Locate natural-gas piping between 18-and 30-inches below finished grade, except in areas subjected to vehicular traffic, where natural-gas piping shall be located between 24- and 30-inches below finished grade. In all cases, when the backfilled trench is to be compacted, the natural-gas piping shall be placed at a depth sufficient to ensure the piping will be covered by not less than 18-inches of backfill material. Comply with requirements in Division 31 Section "Earthwork" for excavating, trenching, and backfilling.
   2. At building, PE piping shall extend to a point 12-inches above finished grade.
   3. Install a safety tracer wire along the entire length of underground piping. Extend safety tracer wire to a point 12-inches above finished grade on the outside gas riser.
   4. Provide a continuous detectable warning tape 12-inches below finished grade, directly above - the entire length of the underground piping. Install detectable warning tape 6-inches below subgrade under paved areas and slabs.

5. Line the trench bottom with a 3-inches thick bedding layer of clean sand, taking care to ensure the pipe will be uniformly and continuously supported over its entire length. Place PE pipe. Cover pipe with clean sand, not less than 6-inches above top of pipe, prior to backfilling the trench. Cover the sand with not less than 12-inches of excavated soil, free of rocks, frozen clods, or debris greater than 3-inches diameter, prior to compacting the backfilled trench.

C. Steel Piping with Protective Coating (Above Ground Only):
1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Replace pipe having damaged protective coating with new pipe.

D. Aboveground Natural-Gas Piping:
1. Pipe Diameter – 2-inches Diameter and Smaller: Steel pipe with malleable-iron fittings and threaded joints.
2. Pipe Diameter – Larger than 2-inches Diameter: Steel pipe with wrought-steel fittings and welded joints.
3. Concealed Piping: All concealed natural-gas piping shall have welded joints.

E. Install fittings for changes in direction and branch connections.
1. Anodeless risers, pieces, or sweeps shall be used when rising up from soil and when penetrating basement walls. Anodeless components shall be secured to the foundation with proper brackets when used as risers.

F. Above-ground, Exterior Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Install steel pipe for sleeves smaller than 6-inches diameter.
2. Install cast-iron "wall pipes" for sleeves 6-inches diameter and larger.

G. Exterior Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

H. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

I. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.4 INDOOR PIPING INSTALLATION

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved by Architect on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building surfaces. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install escutcheons at penetrations of interior walls, ceilings, and floors.
1. New Piping:
a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.

c. Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.
d. Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and set screw.
e. Piping in Equipment Rooms: One-piece, stamped-steel type with set screw.
f. Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

2. Existing Piping:
a. Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
b. Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
c. Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge and set screw or spring clips.
d. Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
e. Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

K. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire stop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

L. Verify final equipment locations for roughing-in.

M. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

N. Drips and Sediment Traps: Provide drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

O. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

P. Concealed natural-gas piping shall be installed according to the International Fuel Code.

Q. Natural-gas piping valves and regulators shall not be installed in concealed spaces.
1. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
2. Prohibited Locations:
a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator hoistways.
b. Do not install natural-gas piping in solid walls or partitions.
c. Do not install natural-gas piping underground below building slabs.

R. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

S. Connect branch piping from top or side of horizontal piping.

T. Provide unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

U. Do not use natural-gas piping as grounding electrode.

V. Provide strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

W. Provide pressure gage upstream and downstream from each pipe regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.5 VALVE INSTALLATION

A. Provide manual gas shutoff valve and pressure regulator for each gas appliance ahead of appliance flexible connector. Valve shall be located in same room as equipment.

B. Provide outdoor underground valves with valve boxes.

C. Provide a shutoff valve, acceptable to the authority having jurisdiction, on the outside riser.

D. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

E. Provide anode for metallic valves in underground PE piping.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes and fittings before assembly.

C. Threaded Joints:
1. Thread pipe with tapered pipe threads according to ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:
1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Flanged Joints: Provide gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

F. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.
1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.7 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hangers and supports specified in Division 23 Section "Hangers and Supports for Piping and Equipment."

B. Provide hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

3.8 CONNECTIONS

A. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

B. Install piping adjacent to appliances to allow service and maintenance of appliances.

C. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

D. Sediment Traps: Provide tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9 LABELING AND IDENTIFYING

A. Comply with requirements in Division 23 Section "Identification for HVAC" for piping and valve identification.

B. Below Grade: Provide detectable warning tape continuously and directly above gas piping, 12-inches below finish grade; 6-inches below sub-grade under pavements and concrete slabs.

C. Provide equipment identifying markers and signs on booster pump packages. Labeling and identification materials are specified in Division 22 “Identification for Plumbing Piping and Equipment”.

3.10 PAINTING

A. Comply with requirements in Division 09 Section, "Painting," for painting interior and exterior natural-gas piping.

3.11 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base.
   1. Construct concrete bases of dimensions indicated or required by contractor or utility company furnished equipment, but not less than 4 inches larger in both directions than supported unit.
   2. Provide dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
   3. Provide epoxy-coated anchor bolts for supported equipment where anchor bolts extend through concrete base, and anchor into structural concrete floor.
   4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   5. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Use 4000-psig, 28-day, compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-In-Place Concrete."

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Test, inspect, and purge natural-gas according to the International Fuel Gas Code and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.13 OUTDOOR PIPING SCHEDULE

A. Underground Natural-Gas Piping: Polyethylene (PE) pipe and fittings joined by heat fusion, or mechanical coupling. Service-line riser with tracer wire shall be terminated in an accessible location.

B. Aboveground Natural-Gas Piping: Steel pipe, with joints as indicated in Article, "Outdoor Piping Installation."

3.14 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

A. Aboveground, branch piping NPS 1 and smaller shall be the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be the following:
   1. Steel pipe with malleable-iron fittings and threaded joints NPS 2 and smaller.
   2. Steel pipe with wrought-steel fittings and welded joints NPS 2-1/2 and larger.
   3. All concealed natural-gas piping shall be welded.
   4. Underground, below building, piping shall not be allowed.

3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG AND LESS THAN 2 PSIG

A. Aboveground piping shall be the following:
   1. Steel pipe with malleable-iron fittings and threaded joints smaller or equal to NPS 2.
   2. Steel pipe with steel welding fittings and welded joints NPS 2-1/2 and larger.
   3. All concealed natural-gas piping shall be in a double wall configuration and vented to the outdoors.

3.16 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter shall be the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.
   3. Cast-iron, non-lubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 and smaller shall be the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.

2. Bronze plug valve.

D. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be the following:
1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, lubricated plug valve.

E. Valves in branch piping for single appliance shall be the following:
1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

3.17 CONTRACTOR STARTUP AND REPORTING

A. Engage a factory-authorized service representative to perform the following startup service:
1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping for tightness.
3. Clean strainer.
4. Verify that booster pump controls are correct for the required application.
5. Prepare a written report documenting services performed.

B. Perform the following startup checks for each booster in the package before starting:
1. Verify bearing lubrication.
2. Start motor.
3. Slowly open discharge valves.
4. Adjust settings.

C. Occupancy Adjustments: When requested, within 12-months of Substantial Completion, perform on-site assistance adjusting boosters to suit actual occupied conditions. Perform two visits to Project outside normal occupancy hours for this purpose.

D. Check piping connections for tightness.

E. Controls: Set for automatic starting, stopping, sequencing, and alarm operations.

F. Final checks before starting: Perform the following preventive maintenance operations:
1. Lubricate bearings.
2. Verify that each booster is free to rotate manually. Do not operate booster if it is bound or drags, until the cause of the trouble has been corrected.

G. Review maintenance and troubleshooting data in Maintenance Manuals.
1. Refer to Division 01Sections "Closeout Procedures" and "Operation and Maintenance Data".
2. Provide a written troubleshooting guide if the Installation and Operation Manual (IOM) does not include one.

3.18 TRAINING AND DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's designated maintenance personnel to adjust, operate, and maintain gas booster packages as specified below.
1. Train Owner's designated maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining gas boosters. The training shall occur after the startup report has been submitted to the Owner. The trainer shall furnish four IOMs for the use of the Owner's personnel during training.
2. Review data in IOMs. All required and recommended maintenance will be reviewed as well as operational troubleshooting. If the IOMs do not include a written troubleshooting guide, one shall be provided for each manual.
a. Refer to Division 01 Section "Closeout Procedures".
b. Refer to Division 01 Section "Operation and Maintenance Data".
3. Schedule training with Owner, through Architect, with at least 7-days advance notice.

B. Demonstrate proper operation of equipment to commissioning agent and the Owner's designated maintenance personnel, including functional performance requirements under both local and building automation system control, as well as project-specific commissioning requirements.

END OF SECTION

HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
   1. Hot-water heating piping.
   2. Chilled-water piping.
   3. Ground Loop condenser -water piping.
   4. Ground Loop make-up-water piping.
   5. Condensate-drain piping.
   6. Air vent piping.
   7. Safety-valve-inlet and -outlet piping.

1.2 DEFINITIONS

A. PTFE: Polytetrafluoroethylene.

B. Concealed Locations: Spaces above ceilings, Spaces in Furred walls

C. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

D. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

1.3 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
   1. Hot-Water Heating Piping: 150 psig at 250 deg F .
   2. Chilled-Water Piping: 150 psig at 100 deg F.
   3. Ground Loop Water Piping: 150 psig at 250deg F.
   4. Makeup-Water Piping: 80 psig at 100 deg F.
   5. Air Conditioning Condensate-Drain Piping: 100 deg F
   6. Air-Vent Piping: 200 deg F.
   7. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

1.4 SUBMITTALS

A. Product Data: For each type of the following:
   1. Pressure-seal fittings.
   2. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
   3. Air control devices.
   4. Chemical treatment.
   5. Hydronic specialties.

B. Shop Drawings: Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops. Submittal shall be drawn in AutoCad latest edition. Copies of design drawings are not acceptable. Provide both AutoCad files and hard copies.”

C. Field quality-control test reports.
   1. Submit written reports documenting the activities required to be performed in PART 3. These reports are to be submitted two weeks after the startup is completed.

D. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

E. Record Drawings: Detail, at 1/4 scale, the actual piping installation layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the

same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops. Submittal shall be drawn in AutoCad latest edition. Provide both AutoCad files and hard copies."

1.5 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

B. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
   3. All welders certificates shall be on file at project site

D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.6 DELIVERY, STORAGE AND HANDLING

A. Follow manufacturer's recommendations for handling, unloading and storage.

B. Storage: Store per manufacturer's written recommendations. Store indoors in a warm, clean, dry place where pipe will be protected from weather, construction traffic, dirt, dust, water and moisture.

1.7 EXTRA MATERIALS

A. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

1.8 WARRANTY

A. Written manufacturers warranty covering parts and labor for a period of one year from substantial completion, or eighteen months from shipment, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following manufacturers:
   1. Wrought Copper Tube and Fittings: No preference.
   2. Copper or Bronze Pressure-Seal Fittings:
      a. Stadler-Viega.
      b. Nibco
   3. Dielectric Unions: No preference.
   4. Dielectric Flanges: No preference.
   5. Dielectric Flange Kits:
      a. Advance Products and Systems, Inc.
   6. Dielectric Couplings: No preference.
   7. Dielectric Nipples: No preference.
   8. Bronze, Calibrated-Orifice, Balancing Valves:
      a. Armstrong Pumps, Inc.
      b. Bell and Gossett Domestic Pump; a division of ITT Industries.
      c. Flow Design Inc.
      d. Griswold Controls.
      e. Nexus
      f. Taco.
   9. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
      a. Armstrong Pumps, Inc.
      b. Bell and Gossett Domestic Pump; a division of ITT Industries.

c. Flow Design Inc.
d. Griswold Controls.
e. Nexus.
f. Taco.

10. Diaphragm-Operated, Pressure-Reducing Valves:
    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell and Gossett Domestic Pump; a division of ITT Industries.
    d. Spence Engineering Company, Inc.
    e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
11. Diaphragm-Operated Safety Valves:
    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell and Gossett Domestic Pump; a division of ITT Industries.
    d. Spence Engineering Company, Inc.
    e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
12. Automatic Flow-Control Valves (New Construction Projects Only):
    a. Flow Design Inc.
    b. Griswold Controls.
    c. Nexus
13. Manual Air Vents: No preference.
14. Automatic Air Vents: No preference.
15. Pressure Fill System:
    a. Armstrong.
    b. Bell and Gossett.
    c. Taco.
16. Bladder-Type Expansion Tanks:
    a. Amtrol, Inc
    b. Armstrong.
    c. Bell and Gossett.
    d. Taco.
    e. Wessels
17. Tangential-Type Air Separator:
    a. Armstrong.
    b. Bell and Gossett.
    c. Taco.
18. Y-Pattern Strainers:
    a. Mueller Steam Specialties.
    b. Piping Specialties Inc.
    c. Spencer.
19. Basket Strainers:
    a. Mueller Steam Specialties.
    b. Piping Specialties Inc.
    c. Spencer.
20. Stainless Steel Bellow, Flexible Connectors:
    a. Mason.
    b. Metraflex
    c. Hyspan
21. Double Spherical, Rubber Flexible Connectors with control rods:
    a. Mason.
    b. Metraflex
    c. Flexicraft
22. Combination Hydronic Units:
    a. Flow Design Inc.
    b. Griswold Controls.
    c. Nexus
    d. Bell and Gossett

e. Armstrong
f. TA
g. Taco

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K (below ground installations).

C. Wrought-Copper Fittings: ASME B16.22.

D. Copper or Bronze Pressure-Seal Fittings:
1. Housing: Copper.
2. O-Rings and Pipe Stops: EPDM.
3. Tools: Manufacturer's special tools.
4. Minimum 200-psig working-pressure rating at 250 deg F.

E. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in PART 3 "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Class 125 as indicated in PART 3 "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 as indicated in PART 3 "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Class 150 as indicated in PART 3 "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250; raised ground face, and bolt holes spot faced as indicated in PART 3 "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

I. Grooved Mechanical-Joint Fittings and Couplings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Anvil International, Inc.
b. Central Sprinkler Company; a division of Tyco Fire and Building Products.
c. National Fittings, Inc.
d. S. P. Fittings; a division of Star Pipe Products.
e. Victaulic Company.
2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings. Fittings shall not be used in place of or as flexible connections.
3. Couplings: Ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

2.4 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

E. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions:
1. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges:
1. Factory-fabricated companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric-Flange Kits:
1. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings:
1. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F.

G. Dielectric Nipples:
1. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.6 VALVES

A. Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 control specification sections.

C. Bronze, Calibrated-Orifice, Balancing Valves:
1. Body: Bronze, ball or plug type with calibrated orifice or venturi.
2. Ball: Brass or stainless steel.
3. Plug: Resin.
4. Seat: PTFE.
5. End Connections: Threaded or socket.
6. Pressure Gage Connections: Integral seals for portable differential pressure meter.
7. Handle Style: Lever, with memory stop to retain set position.
8. CWP Rating: Minimum 125 psig.
9. Maximum Operating Temperature: 250 deg F.

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
1. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
2. Ball: Brass or stainless steel.
3. Stem Seals: EPDM O-rings.
4. Disc: Glass and carbon-filled PTFE.
5. Seat: PTFE.
6. End Connections: Flanged or grooved.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.

9. CWP Rating: Minimum 125 psig (860 kPa).
10. Maximum Operating Temperature: 250 deg F (121 deg C).

E. Diaphragm-Operated, Pressure-Reducing Valves:
1. Body: Bronze or brass.
2. Disc: Glass and carbon-filled PTFE.
3. Seat: Brass.
4. Stem Seals: EPDM O-rings.
5. Diaphragm: EPT.
6. Low inlet-pressure check valve.
7. Inlet Strainer: stainless steel, removable without system shutdown.
8. Valve Seat and Stem: Noncorrosive.
9. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves:
1. Body: Bronze or brass.
2. Disc: Glass and carbon-filled PTFE.
3. Seat: Brass.
4. Stem Seals: EPDM O-rings.
5. Diaphragm: EPT.
6. Wetted, Internal Work Parts: Brass and rubber.
7. Inlet Strainer: stainless steel, removable without system shutdown.
8. Valve Seat and Stem: Noncorrosive.
9. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Automatic Flow-Control Valves (New Construction Projects Only):
1. Body: Brass or ferrous metal.
2. Piston and Spring Assembly: Stainless steel, tamper proof, self cleaning, and removable.
3. Combination Assemblies: Include bonze or brass-alloy ball valve.
4. Identification Tag: Marked with zone identification, valve number, and flow rate.
5. Size: Same as pipe in which installed.
6. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
7. Minimum CWP Rating: 175 psig.
8. Maximum Operating Temperature: 250 deg F.

2.7 AIR CONTROL DEVICES

A. Manual Air Vents:
1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2 .
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

B. Automatic Air Vents:
1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2
5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 240 deg F.

C. Bladder-Type Expansion Tanks:
1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

2. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. Tangential-Type Air Separators:
1. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
4. Blowdown Connection: Threaded.
5. Size: Match system flow capacity.

2.8 CHEMICAL TREATMENT

A. See Division 23 chemical treatment specification

2.9 PRESSURE FILL SYSTEM

A. Provide a complete factory packaged automatic glycol / make-up water fill system unit per system as manufactured by Bell and Gossett (GMU) or equal by Taco, Armstrong as scheduled. The unit shall consist of a base, 55 gallon tank (steel or polyethylene) with removable lid, fill vent opening, observable fluid level indicator scale (gallons), Y-strainers, isolation valves, triple combination shut off – Non slam check – calibrated balance valves, open drip proof motor, pump, expansion tank, motor contactor, pressure controls, interconnecting piping, low level safety shut down, remote alarm contacts, indicator light, fill valve (automatic for water systems, manual for glycol systems), discharge pressure gauge, discharge line pressure reducing valve, isolation valves, pressure gauge and single point power connection.

2.10 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:
1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. Blow off ball valve with hose end and cap.
5. CWP Rating: 125 psig.

B. Basket Strainers:
1. Body: ASTM A 126, Class B, high-tensile cast iron with quick opening spring assist hinged cover, bottom drain connection and support legs.
2. End Connections: flanged ends .
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area. Provide second spare strainer and stainless-steel basket.
4. CWP Rating: 125 psig.

C. Stainless-Steel Bellow, Flexible Connectors:
1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

D. Double Spherical, Rubber, Flexible Connectors with control rods:
1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig .
5. Maximum Operating Temperature: 250 deg F.

E. Combination Hydronic Units:
1. Hydronic units which combine multiple component functions into one (isolation valve, y-strainer, calibrated balance valve, air vent, union and PandT taps) may be used to minimize space and labor provided all functionality of the combined unit is equal to the individual components and all maintenance can be performed without draining down additional parts of the system. Combination

units shall meet/better all material/rating/performance requirements of individual parts specified in Part 2.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 ½" and smaller, shall be:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure-seal joints.

B. Hot-water heating piping, aboveground, NPS 3" to NPS 4" shall be:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure-seal joints.
   2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

C. Hot-water heating piping, aboveground, NPS 5 inch and larger, shall be the following:
   1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints. Grooved mechanical joint couplings and fittings may be used in exposed locations (not allowed above ceilings, in shafts or soffits).

D. Hot-water heating piping installed belowground and within slabs shall be the following:
   1. Type K, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

E. Chilled-water piping, aboveground, NPS 2 1/2" and smaller, shall be:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure-seal joints.

F. Chilled-water piping, aboveground, NPS 3" to NPS 4" shall be:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure-seal joints.
   2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

G. Chilled-water piping, aboveground, NPS 4 inch and larger, shall be the following:
   1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints. Grooved mechanical joint couplings and fittings may be used in exposed locations. (not allowed above ceilings, in shafts or soffits).

H. No Chilled-water piping shall be installed belowground and or within slabs

I. Dual-temperature heating and cooling water piping, aboveground, NPS 2 1/2" and smaller shall be the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure seal joints.

J. Ground loop water piping, aboveground, NPS 3" to NPS 4" shall be the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure seal joints.
   2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

K. Ground loop water piping, aboveground, NPS 4 inch and larger, shall be the following:
   1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints. Grooved mechanical joint couplings and fittings may be used in exposed locations. (not allowed above ceilings, in shafts or soffits).

L. No dual-temperature heating and cooling water piping shall be installed belowground and within slabs

M. Makeup-water piping installed aboveground shall be the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure sealed joints.

N. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

O. Condensate-Drain Piping: Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints

P. Air-Vent Piping:
   1. Inlet: Same as service where installed.
   2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

Q. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.2 VALVE APPLICATIONS

A. Install valves as indicated on drawings and details. When not indicated on drawings / details at a minimum provided valves as indicated in 3.2.B through G.

B. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

C. Install calibrated-orifice, balancing valves at each branch connection to return main.

D. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

E. Install check valves at each pump discharge and elsewhere as required to control flow direction.

F. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

G. Install pressure-reducing valves with strainer and isolation valve at makeup-water connection to regulate system fill pressure.

3.3 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

L. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

M. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

N. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

O. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

P. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

Q. Install valves according to Division 23.

R. Install unions in piping, NPS 2-1/2” and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

S. Install flanges in piping, NPS 3” and larger, at final connections of equipment and elsewhere as indicated.

T. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

U. Install expansion loops, expansion joints, anchors, and pipe alignment guides.

V. Identify piping as specified in Division 23.

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 23. Comply with the following requirements for maximum spacing of supports.

B. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
7. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.
8. NPS 6: Maximum span, 17 feet; minimum rod size, 1/2 inch.
9. NPS 8: Maximum span, 19 feet; minimum rod size, 5/8 inch.
10. NPS 10: Maximum span, 20 feet; minimum rod size, 3/4 inch.
11. NPS 12: Maximum span, 23 feet; minimum rod size, 7/8 inch.
12. NPS 14: Maximum span, 25 feet; minimum rod size, 1 inch.
13. NPS 16: Maximum span, 27 feet; minimum rod size, 1 inch.
14. NPS 18: Maximum span, 28 feet; minimum rod size, 1-1/4 inches.
15. NPS 20: Maximum span, 30 feet; minimum rod size, 1-1/4 inches.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch
7. NPS 4: Maximum span, 10 feet; minimum rod size, 3/8 inch.

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

F. PIPE JOINT CONSTRUCTION

G. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

H. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

I. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

J. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

K. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

L. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

M. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

N. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.5 HYDRONIC SPECIALTIES INSTALLATION

A. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.

B. Install piping from boiler air outlet or air separator to expansion tank with a 2 percent upward slope toward tank.

C. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

D. Install bladder tanks per manufacturer's instructions. Install tank fitting and charge tank. Use manual vent for initial fill to establish proper water level in tank.
1. Install tank fittings that are shipped loose.
2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

E. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system Project requirements.

F. Provide 4" concrete pad beneath pressure fill systems. Install per manufacturers recommendations. Select associated pressure regulators for required system fill pressure in mid span of regulator range.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23.

3.7 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:

B. Provide cleaning and chemical treatment per 232500 specification.

C. Add initial chemical treatment and maintain water quality as recommended by chemical treatment company for the first year of operation.

D. Fill systems indicated to have antifreeze or glycol solutions with the following concentrations:
1. Hot-Water Heating Piping: Minimum 20 percent propylene glycol.
2. Ground loop Water Piping: Minimum 20 percent propylene glycol.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:
1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used (compressed air may not be used).
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:
1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

3.9 COMMISSIONING AND DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain equipment. Refer to Division 01 Section "Demonstration and Training."
1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining the pressure fill system and other applicable equipment. The training will occur after the startup report has been provided to the owner and the trainer will provide two (2) Installation and Operations manuals for the use of the owner’s personnel during training.
2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational trouble shooting. If the IOM does not include a written trouble shooting guide one will be provided.
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.
4. Training will occur in one (1) two (2) hour session.

B. Demonstrate proper operation of equipment to commissioning agent or designated owners personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements in Division 01 and 23.

C. Video record the training sessions. The manufacturer may submit a standard training video training CD for review as an alternate to videotaping of the training session. The standard video must be reviewed and accepted by the owner/commissioning authority for the alternate to be acceptable.

END OF SECTION

GROUND-LOOP HEAT EXCHANGER

PART 1 - GENERAL

1.1 WORK INCLUDES

A. Base Bid:
   1. Provide vertical ground loop heat exchangers as specified herein.
   2. Provide a complete geothermal loop field installation. All materials, drilling, excavation, hauling of backfill, pumping, soil compaction, and labor required.

1.2 SECTION INCLUDES

A. Vertical Well Type Ground Loop Geothermal Heat Exchanger.

1.3 RELATED REQUIREMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 and 2 Specification Sections, apply to this Section.

B. Related Sections include the following:
   1. Section 230503 – General Provisions for HVAC Work
   2. Section 230593 - Testing, Adjusting, and Balancing for HVAC work
   3. Section 238146 - Water Source Unitary Heat Pumps

C. Should the Drawings and/or Specifications require methods of construction, installation or materials, which the Contractor cannot guarantee for the indicated period of installation for this project, it shall be the responsibility of the Contractor to so inform the Architect/Engineer in writing before submitting his bid. If no such exception is received, the Contractor shall be held responsible to provide the method of construction, installation or material, which will be guaranteed for the indicated period of time. After bids are received no allowance will be made for oversight by Bidder. "The Contractor shall liable to the Owner or Architect/Engineer for any additional cost resulting from errors, inconsistencies, or omissions in the Contract Documents unless the Contractor recognized or should have recognized such error, inconsistency, or omission, and failed to report it to the Architect/Engineer prior to bid due date, in which case the Contractor shall not be entitled to an increase in the Contract Sum or Contract Time and the Contractor shall bear all attributable costs for correction/replacement/adaptation.

D. When there is any form of errors, inconsistencies, or omissions in the Contract Documents (between Specifications and Drawings) the ventilation/heating contractor shall provide the cost in their bid for the higher/more expensive option/means/method/material/OEM requirements for this project. Failure to notify the Architect/Engineer prior to bid to clarify/define/adjust the Contract Documents prior to bid due date, in which case the Contractor shall not be entitled to an increase in the Contract Sum or Contract Time and the Contractor shall bear all attributable costs for correction replacement/adaptation.

E. Purchasing of equipment/components/device/items shown on the contract documents that may have errors, inconsistencies, omissions, or become an obsolete product from an OEM does not entitle the ventilation/heating contractor to change orders or request for proposals. The practice of purchasing equipment/components/device/items and delivering to the site and then issuing request for information for discoveries of errors, inconsistencies, omissions, or inadequacies shall not be entitlement to change orders nor request for proposals. It shall be the responsibility to provide professional practice of having prior knowledge and expertise in all equipment/components/device/items purchased for the OEMs for the installation of this project.

F. This design has been prepared in accordance with the materials standards and accepted installation practices of the International Ground Source Heat Pump Association (IGSHPA). The Contractor shall comply with these standards and practices along with all state and local regulations pertaining to the installation.

G. The Contractor shall verify exact locations of utilities in the loop field. Some areas may require hand digging to locate utilities. The Contractor must include in the bid price the repair of any sewer, domestic water, electrical, communication or any service line that may be damaged during the construction of this project. Any offsets required to route over or under existing lines shall also be included in the bid price of the project.

1.4 REFERENCES

A. ASTM D2610 – Solid Wall HDPE Conduit Based On Controlled Outside Diameter.

B. ASTM D2683 – Socket Fusion Fittings.

C. ASTM D3261 – Butt/Saddle Fusion Fittings.

D. ASTM D3350-93 – Polyethylene Plastic Pipe and Fittings.

E. International Ground Source Heat Pump Association (IGSHPA).

1.5 PERFORMANCE REQUIREMENTS

A. The Contractor must have on this project a certified IGSHPA installer. The Contractor performing this work must have a minimum of five years experience in performing underground closed circuit, earth coupled, vertical heat exchanger, including systems of 200 tons or larger. Contractor must provide a minimum of 3 references from similar projects completed within the last 10 years.

B. Geothermal Heat Exchanger Fabricators must be heat fusion certified by an authorized high density polyethylene (HDPE) pipe manufacturer's representative of the brand of pipe used. Certification must include successful completion of a written heat fusion exam, as well as demonstrating proper heat fusion techniques under the direct supervision of the authorized HDPE pipe manufacturer's representative.

C. Certified technicians must attend a retraining school annually. A single failure of a fusion joint will void the certification, and the technician must be retested to demonstrate satisfactory performance.

D. Local, State, and Federal laws and ordinances, as they pertain to buried pipe systems, shall be strictly followed or a variance obtained.

E. Verify that survey benchmark and intended elevation of grade at well field prior to beginning work.

F. Grouting compound shall be certified and listed by NSF (National Sanitation Foundation International) to ANSI/NSF Standard 60, "Drinking Water Treatment Chemicals - Health Effects".

G. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
   1. Ground-Loop, Heat-Pump Piping: 160 psig.

1.6 SUBMITTALS

A. Product Data: For the following:
   1. Pipe and fittings.
   2. Joining method and equipment.
   3. Retain subparagraph below for climates and piping placement that require freeze protection.
   4. Propylene glycol solution.

B. Before geothermal heat exchanger construction begins, the Contractor must submit shop drawings to the Design Engineer. The shop drawings shall include all applicable manufacturer's material specifications, warranties, installer qualifications, material safety data sheets for all materials used in the geothermal installation, all polyethylene piping and fitting materials, U-bend assemblies, and testing and flushing procedure. No substitutions will be allowed without authorization from the Design Engineer. Substitution rules as per PBC Book 2 "Standard Terms and Conditions for Construction Contracts" shall still apply.

C. Submit detailed 1"=20' scale CAD drawing showing bore field layout, including site utilities and obstructions. Drawing shall include all horizontal pipe routing.

D. Submit all underground piping pressure test results.

1.7 PROTECTION

A. Protect trees, shrubs, lawns, rock outcropping, and other features remaining as a portion of final landscaping. Place excavated material from trench on hard surface area, heavy mil sheet plastic or sheet vinyl to minimize damage to grassed areas.

B. Protect benchmarks, existing structures, fences, sidewalks, paving, and curbs from equipment and vehicular traffic.

C. Protect above and below grade utilities that are to remain.

D. Protect excavations by shoring, bracing, sheet piling, underpinning, or other methods required to prevent cave-in or loose soil from falling into excavation.

E. Notify Engineer of unexpected subsurface conditions.

F. Protect bottom of excavations and soil adjacent to and beneath foundations from freezing.

G. Refer to Section 230503 for other requirements.

PART 2 - PRODUCTS

2.1 PIPES AND FITTINGS

A. PE Pipe: ASTM D 2239, SIDR Numbers 9 for vertical pipes and 11 for horizontal piping; with PE compound number required to achieve required system working pressure.
   1. Molded PE Fittings: ASTM D 2683 or ASTM D 3261, PE resin, socket- or butt-fusion type, made to match PE pipe dimensions and class.

B. U-Bend Assembly: Factory fabricated with embossed depth stamp every 36 inches from U-bend. The vertical heat exchanger will have one-piece U-bend with pipe lengths long enough to reach grade from the bottom of the bore so no field fusions are required below the header pit. U-bends fabricated from two elbows are not permitted.

C. Approved pipe manufacturers are Chevron Phillips Driscoplex 5300, Vanguard, Plexco, Centennial Plastics, Endot Industries.

2.2 BENTONITE GROUT (THERMALLY ENHANCED)

A. Material: Thermally enhanced bentonite grout shall be used to seal and backfill each vertical u-bend well bore of the closed-loop ground heat exchanger to ensure proper thermal contact with the earth and to ensure the environmental integrity of each vertical bore column. The grouting material shall remain in a plastic state (moldable) throughout the life of the system and shall not generate heat during the hydration process. No other backfill material shall be accepted.

B. Thermal Conductivity: The thermal conductivity of the grouting compound must be 1.0 Btu/hr-ft-°F or greater, if used alone.

C. Permeability: The grout mixture shall also have a maximum permeability rate of less than 6.9 x 10-8 cm/s as determined by using the "Falling-Head Method" (defined in the United States Army Corp of Engineers' Civil Engineering Manual No. EM 1110-2-1906, "Laboratory Soils Testing") as recommended by the U.S. Environmental Protection Agency to ensure proper sealing. Permeability shall be verified by an independent lab, with a copy of the report being supplied upon request from the Engineer.

D. Total Solids and Enhancement Compound Percentage: The thermally enhanced bentonite grout used shall have minimum manufacturers recommended mixture of 250 lb solids. The thermal enhancement compound (high-grade silica compound) shall constitute a minimum of 50 lb by weight of the aqueous slurry.

E. Packaging: Grouting materials shall be pre-manufactured and packaged prior to delivery to the site. If the grouting material supplier does not supply sand additive, Contractor shall obtain pre-approval from the Engineer prior to site use as a thermal enhancement additive.

F. Product: Grouting material shall be Black Hills Bentonite's Thermal Grout Select as supplied by GeoPro, Inc., or equivalent pre-approved by the Design Engineer.

2.3 BOREHOLE BACKFILL

A. Backfill below Surface Seal: Natural or manufactured sand specified in Division 02.

2.4 ANTIFREEZE SOLUTION

A. Propylene Glycol: Minimum 20 percent propylene glycol with corrosion inhibitors and environmental stabilizer additives to be mixed with water to protect the piping circuit and connected equipment from physical damage from freezing or corrosion.

B. Quantity: Sufficient solution for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

C. Dilution Water: Chloride content shall be less than 25 ppm, sulfate less than 25 ppm, and hardness less than 100 ppm.

2.5 FIELD LOCATION

A. Bore locations shall be confined to the area designated on the accompanying drawings. Bore locations to be individually surveyed after drilling is complete, but before horizontal trenching is done.

B. Permanent corner markers shall be provided at the four corners of the bore field. Place 18-inch square concrete paving stone flush with grade at each corner.

PART 3 - EXECUTION

3.1 PREPARATION

A. Identify required lines, levels, contours, and datum.

B. Identify known underground, above ground, and aerial utilities. Stake and flag locations.

C. Notify the Owner and coordinate the removal and relocation of utilities. At the Owner's direction, the Contractor shall notify utility company to remove and relocate utilities.

3.2 DRILLING

A. The vertical boreholes will be drilled to a depth allowing complete insertion of the vertical heat exchanger to its specified depth. The maximum borehole diameter will be six inches. If a larger diameter is required, prior approval must be granted by the Design Engineer.

B. Provide casing material as needed to prevent collapse of the upper bore while drilling into the limestone. Refer to drilling log or obtain subsurface conditions from another source.

3.3 U-BEND HEAT EXCHANGER ASSEMBLY

A. The U-bend heat exchanger pipe shall be air fill pressurized to 60 psig to check for leaks before insertion. If necessary, an iron (sinker) bar can be attached at the base of each vertical heat exchanger u-bend to overcome buoyancy. This iron bar will have all sharp edges adequately taped to avoid scarring and/or cutting of the HDPE pipe. No driving rod that is pulled out after U-bend insertion will be allowed. The entire assembly shall be inserted to the specified depth in the borehole.

3.4 GROUTING PROCEDURES

A. The U-bend heat exchanger shall be pressure grouted from the bottom up to the ground surface in a continuous fashion using a one inch HDPE tremie pipe. The tremie pipe will be pulled out during the grouting procedure, maintaining the pipe’s end just below grout level within the borehole. All state regulations will be met for borehole grouting of a vertical heat exchanger.

B. Slurry mixture and grouting process shall conform to “Grouting Procedures: As published by IGSHPA 1991.”

3.5 HEAT FUSION PIPE JOINING

A. All underground pipe joining shall be heat fused by socket, butt, or saddle (sidewall) fusion in accordance to ASTM D2610, ASTM D2683, and the manufacturer's heat fusion specifications. The operator shall be heat fusion certified and experienced in executing quality fusion joints.

3.6 EXCAVATION AND BACKFILLING FOR PIPING

A. The Contractor shall do all excavating, backfilling, shoring, bailing, and pumping for the installation of their work and will perform necessary grading to prevent surface water from flowing into trenches or other excavations. Sewer lines shall not be used for draining trenches, and the end of all pipe and conduit shall be kept sealed and lines left clean and unobstructed during construction. Only material suitable for backfilling shall be piled a sufficient distance from banks of trenches to avoid overloading. Unsuitable backfill material shall be removed as directed by the Design Engineer.

B. Sheathing and shoring shall be done as necessary for protection of work and personnel safety. Unless otherwise indicated, excavation shall be open cut except for short sections. The Contractor shall install geothermal marking (warning) tape 18 inches above all horizontal/header piping.

C. Prior to drilling or trenching, the Contractor shall be responsible for reviewing the location of underground utilities with the Owner’s representative. Contractor shall arrange for utility marking. Existing utility lines uncovered during excavation shall be protected from damage during excavation and backfilling.

D. Underpin adjacent structures that will be damaged by excavation work, including utilities and pipe chases.

E. Excavate subsoil required to accommodate site structures, construction operations, and other work.

F. Machine slope banks to angle of repose or less, until shored.

G. Excavation cut not to interfere with normal 45 degree bearing splay of foundation, except where excavation support system is used.

H. Grade top perimeter of excavation to prevent surface water from draining into excavation.

I. Hand trim excavation. Remove loose matter.

J. Notify Engineer immediately of unexpected subsurface conditions.

K. Stockpile and protect excavated material in area designated on site. Remove clean excess material not being reused to location on site designated by Owner. Remove from site excess excavated material not determined to be clean. Legally dispose of excess excavated material.

3.7 PIPE INSTALLATION

A. The U-bend ends shall be sealed with fusion caps or tape prior to insertion into the borehole. Reasonable care shall be taken to ensure the geothermal loop field pipe is not crushed, kinked, or cut. Should any pipe be damaged, the damaged section shall be cut out and the pipe reconnected by heat fusion.

B. The U-bend heat exchanger must be connected as indicated on the plans. The header design accounts for balanced flow, as well as flushing and purging flow rates. No variations can be made in the circuit hookup or the pipe sizes indicated without approval from the Design Engineer. The minimum bend radius for each pipe size shall be 25 times the nominal pipe diameter or the pipe manufacturer's recommendations, whichever is greater. The depth of all headers and supply and return piping is indicated on the plans or must be maintained below the frost line.

C. Circuits shall be pressure tested before any backfilling of the header trenches is executed. The individual circuits shall be pressure tested with water at 100 psig, however, not to exceed SDR 9 pipe working pressure at bottom of vertical U-bend heat exchanger.

3.8 TESTING AND CLEANING

A. During installation, all trash, soil, small animals, and other organic material shall be kept out of the pipe. Ends of the HDPE pipe shall be sealed until the pipe is joined to the circuits.

B. Before backfilling the trenches, all systems shall be flushed and purged of air and flow tested to ensure all portions of the closed-loop ground heat exchanger are properly flowing. A portable temporary purging unit shall be used.

C. Flushing and Purging: Each supply and return circuit shall be flushed and purged with a minimum water velocity of two feet per second. Flush until clean, including removal of all cuttings, shavings, mud, sand, and debris. The lines shall be left filled with clean water and then pressure tested. If connection to the manifold is not immediate, piping must be capped.

D. Utilizing the purging unit, conduct a pressure and flow test on the ground heat exchanger to ensure the system is free of blockage. If the flow test indicates blockage, locate blockage using manufacturer’s recommendation, remove blockage, then re-purge and conduct the pressure and flow test again until all portions of the system are flowing properly.

E. The Contractor shall be responsible for correcting any problems and/or paying for any damage caused by any debris left in the lines, after the flushing procedure has been completed, that enter the building and plug strainers or otherwise negatively impact the performance of the building systems.

F. Hydrostatic Testing:
   1. Fill and pressure test each piping circuit to 100 psig for eight hours prior to the backfilling of the trenches.
   2. Each joint shall be visually and physically inspected, using industry standards, for cold joints. Any joints failing the test shall be completely removed from the system and a new joint or fitting installed. with the test being repeated.
   3. Correction of any piping leaks will be the responsibility of the Contractor who installed the piping. A second leak test will be required.
   4. Before final connection of the plastic piping lines to the building system main supply and return loops, each circuit shall be flushed thoroughly and left filled with clean water.

G. During piping installation, the Engineer has the option to test the depth of ten holes at random. If the length is as specified, the piping may be tested and covered. If shorter than the length specified, the heat exchanger field or the individual heat exchanger must be increased as specified. In addition, all heat exchanger holes must be uncovered and have their lengths verified and vertical and horizontal tolerances verified. At the Owner Representative’s option, the heat exchanger field will be required to be increased to the specified lengths or replaced.

GROUND-LOOP HEAT EXCHANGER

3.9 DEMONSTRATION AND TRAINING

A. Training of the Owner's operation and maintenance personnel is required in cooperation with the Owner and/or Owner's Representative. Provide competent, factory authored personnel to provide instruction to operation and maintenance personnel concerning the location, operation and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Owner and/or Owner's Representative after submission and approval of formal training plans. Refer to section Demonstration and Training - Section 01820, for training requirements. Refer to section General Commissioning Requirements -Section 01100, for further training requirements

3.10 ANTIFREEZE SOLUTION FILL

A. Fill system with required quantity of propylene glycol and water to provide 19 deg F freezing temperature.

B. Test the dilute solution using gas chromatography to verity concentration of propylene glycol, and forward report to Architect.

END OF SECTION

HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:
   1. Close-coupled, in-line centrifugal pumps.
   2. Separately coupled, base-mounted, end-suction centrifugal pumps.
   3. Automatic condensate pump units.

1.2 DEFINITIONS

A. Buna-N: Nitrile rubber.

1.3 SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
   1. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

D. Startup Reports: Submit reports documenting the activities required to be performed in PART 3. These reports are to be submitted two weeks after the startup is completed.

E. Training Reports: Submit reports on training documenting dates and attendance.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Mechanical Seals: One mechanical seals for each pump.

HYDRONIC PUMPS

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following manufacturers:
   1. Close-Coupled, In-Line Centrifugal Pumps:
      a. Armstrong Pumps Inc.
      b. Bell & Gossett; Div. of ITT Industries.
      c. Taco, Inc.
   2. Separately Coupled, Base-Mounted, End-Suction Centrifugal Pumps:
      a. Armstrong Pumps Inc.
      b. Bell & Gossett; Div. of ITT Industries.
      c. Taco, Inc.
   3. Automatic Condensate Pump Units:
      a. Aurora Pump; Division of Pentair Pump Group.
      b. Flowserve Corporation; Div. of Ingersoll-Dresser Pumps.
      c. Little Giant Pump Co.; Subsidiary of Tecumseh Products Co.
      d. MEPCO (Marshall Engineered Products Co.).

2.2 CLOSED – COUPLED IN LINE CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 225 deg F.

B. Pump Construction:
   1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and threaded companion-flange or union end connections. Provide all iron construction for swimming pool applications.
   2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance. Provide non-ferrous construction for swimming pool applications.
   3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
   4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
   5. Pump Bearings: Permanently lubricated ball bearings where available, Oil lubricated; bronze-journal or thrust type if permanently lubricated is not available..

C. Motor: Single speed, with permanently lubricated (less then 5hp) , grease-lubricated (5hp and over) ball bearings, unless otherwise indicated; and rigidly mounted to pump casing. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.3 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 225 deg F.

B. Pump Construction:
   1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections. Provide all iron construction for swimming pool applications.
   2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
   3. Pump Shaft: Steel, with copper-alloy shaft sleeve. Provide non-ferrous impellor for swimming pool applications.

4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket.
5. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings.

C. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration. EPDM coupling sleeve for variable-speed applications.

D. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

E. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

F. Motor: Single speed, with permanently lubricated (5hp and smaller), grease-lubricated (pumps over 5hp)] ball bearings, unless otherwise indicated; secured to mounting frame, with adjustable alignment. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.4 AUTOMATIC CONDENSATE PUMP UNITS

A. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch minimum, electrical power cord with plug.

2.5 PUMP SPECIALTY FITTINGS

A. Suction Diffuser: Angle pattern, 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support.

B. Triple-Duty Valve: Angle or straight pattern, 175-psig pressure rating, cast-iron body, pump-discharge fitting; with drain plug and bronze-fitted shutoff, balancing, and check valve features. Brass gage ports with integral check valve, and orifice for flow measurement.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES

A. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Division 23 Section "Basic HVAC Materials and Methods."
1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.3 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Install continuous-thread hanger rods and spring hangers with vertical-limit stop of sufficient size to support pump weight. Vibration isolation devices are specified in Division 23 Section "Vibration Controls for HVAC." Fabricate brackets or supports as required. Hanger and support materials are specified in Division 23 Section "Hangers and Supports for Piping and Equipment."

E. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and spring hangers with vertical-limit stop of sufficient size to support pump weight. Vibration isolation devices are specified in Division 23 Section "Vibration Controls for HVAC." Hanger and support materials are specified in Division 23 Section "Hangers and Supports for Piping and Equipment."

F. Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.
   1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.
   2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

G. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

3.4 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.

B. Comply with pump and coupling manufacturers' written instructions.

C. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install triple-duty valve on discharge side of pumps.

F. Install suction diffuser and shutoff valve on suction side of pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.

I. Install check valve and gate or ball valve on each condensate pump unit discharge.

J. Install electrical connections for power, controls, and devices.

K. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Division 26 Section "Conductors and Cables for Electrical Systems."

3.6 CONTRACTOR STARTUP AND REPORTING

A. Engage a factory-authorized service representative to perform startup service. Startup service includes the testing, inspections and startup test reports.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Check piping connections for tightness.
   3. Clean strainers on suction piping.
   4. Perform the following startup checks for each pump before starting:
      a. Verify bearing lubrication.
      b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
      c. Verify that pump is rotating in the correct direction.
   5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
   6. Start motor.
   7. Open discharge valve slowly.

3.7 COMMISSIONING AND DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps. Refer to Division 01 Section "Demonstration and Training."
   1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining chillers. The training will occur after the startup report has been provided to the owner and the trainer will provide two (2) Installation and Operations manuals for the use of the owners personnel during training.
   2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational trouble shooting. If the IOM does not include a written trouble shooting guide one will be provided.
   3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

B. Demonstrate proper operation of equipment to commissioning agent or designated owners personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements in Division 01 or 23.

END OF SECTION

.

REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes refrigerant piping used for air-conditioning applications.

1.2 SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
   1. Thermostatic expansion valves.
   2. Solenoid valves.
   3. Hot-gas bypass valves.
   4. Filter dryers.
   5. Strainers.
   6. Pressure-regulating valves.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
   1. Shop Drawing Scale: 1/4 inch equals 1 foot.

C. Welding certificates.

D. Field quality-control test reports.
   1. Submit written reports documenting the activities required to be performed in PART 3. These reports are to be submitted two weeks after the startup is completed.

E. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.3 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.4 DELIVERY STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.5 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.6 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-134a:
   1. Suction Lines for Air-Conditioning Applications: 115 psig.
   2. Suction Lines for Heat-Pump Applications: 225 psig.
   3. Hot-Gas and Liquid Lines: 225 psig.

B. Line Test Pressure for Refrigerant R-407C:
   1. Suction Lines for Air-Conditioning Applications: 230 psig.
   2. Suction Lines for Heat-Pump Applications: 380 psig.
   3. Hot-Gas and Liquid Lines: 380 psig.

C. Line Test Pressure for Refrigerant R-410A:
   1. Suction Lines for Air-Conditioning Applications: 300 psig.
   2. Suction Lines for Heat-Pump Applications: 535 psig.
   3. Hot-Gas and Liquid Lines: 535 psig.

.

REFRIGERANT PIPING

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Subject to compliance with requirements, provide products by one of the following manufacturers:
1. Refrigerants:
a. Atofina Chemicals, Inc.
b. DuPont Company; Fluorochemicals Div.
c. Honeywell, Inc.; Genetron Refrigerants.
d. INEOS Fluor Americas LLC.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280, Type ACR or type K complying with ASTM B88 or ASTM B819.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Brazing Filler Metals: AWS A5.8.

E. Flexible Connectors:
1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; Type, Grade, and wall thickness as selected in PART 3 piping applications articles.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.

D. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

E. Flanged Unions:
1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 and ductile iron for NPS 2 to NPS 3. Apply rust-resistant finish at factory.
2. Gasket: Fiber asbestos free.
3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
4. End Connections: Brass tailpiece adapters for brazed-end connections to copper tubing.
5. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- long assembly.
6. Pressure Rating: Factory test at minimum 400 psig.
7. Maximum Operating Temperature: 330 deg F.

F. Flexible Connectors:
1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket
2. End Connections:
a. NPS 2 and Smaller: With threaded-end connections.
b. NPS 2-1/2 and Larger: With flanged-end connections.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.4 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:
1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.

2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:
1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:
1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:
1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.
1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 115-V ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with ARI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.

5. Suction Temperature: See Equipment Schedules
6. Superheat: Adjustable.
7. Reverse-flow option (for heat pump applications).
8. End Connections; Socket, flare, or threaded union.
9. Working Pressure Rating: 700 psig.

H. Hot-Gas Bypass Valves: Comply with UL 429, listed and labeled by NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: Internal or External.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and [24] [115] [208]-V ac coil.
8. End connections: Socket.
9. Set Pressure: As required.
10. Throttling Range: Maximum 5 psig.
11. Working Pressure Range: 500 psig.
12. Maximum Operating temperature: 240 deg F.

I. Straight-Type Strainers:
1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

J. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

K. Moisture/Liquid Indicators:
1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

L. Replaceable-Core Filter Dryers: Comply with ARI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated charcoal.
4. End Connections: Socket.
5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
6. Maximum Pressure Loss: 2 psig.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg F.

M. Permanent Filter Dryers: Comply with ARI 730.
1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.

3. Desiccant Media: Activated charcoal.
4. End Connections: Socket.
5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
6. Maximum Pressure Loss: 2 psig.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg F.

N. Mufflers:
1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

O. Receivers: Comply with ARI 495.
1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

P. Liquid Accumulators: Comply with ARI 495.
1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

2.5 REFRIGERANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-22: Monochlorodifluoromethane.

C. ASHRAE 34, R-134a: Tetrafluoroethane.

D. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.

E. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 REFRIGERANT PIPE SIZING:

A. All refrigerant pipe sizing shall be the responsibility of the Contractor in accordance with the equipment manufacturer’s recommendations.

B. Pipe sizing shall be in accordance with the recommendations in the 2010 ASHRAE Handbook – Refrigeration, Chapter 2 – System Practices for Halocarbon Refrigerants.

C. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-134A

A. Suction Lines NPS 4 (DN 100) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Hot-Gas and Liquid Lines: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Hot-Gas and Liquid Lines:
   1. NPS 1-1/2 and Smaller: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or brazed joints.
   2. NPS 4: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or brazed joints.

D. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

3.3 PIPING APPLICATIONS FOR REFRIGERANT R-407C

A. Suction Lines NPS 4 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Hot-Gas and Liquid Lines: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Hot-Gas and Liquid Lines:
   1. NPS 1 and Smaller: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
   2. NPS 1-1/4 to NPS 2: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or brazed joints.
   3. NPS 4: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

D. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

3.4 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 3-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Hot-Gas and Liquid Lines: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Hot-Gas and Liquid Lines: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony brazed joints.

D. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

3.5 VALVE AND SPECIALTY APPLICATIONS

A. Install packed-angle valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install packed-angle valves on inlet and outlet side of filter dryers.

E. Install a full-sized, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
   1. Install valve so diaphragm case is warmer than bulb.
   2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
   3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
   1. Solenoid valves.
   2. Thermostatic expansion valves.
   3. Hot-gas bypass valves.
   4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.6 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Division 23 Sections "Building Automation System (BAS)" and "Building Automation System (BAS) - Sequence of Operation" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:
   1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
   2. Install horizontal suction lines with a uniform slope downward to compressor.
   3. Install traps and double risers to entrain oil in vertical runs.
   4. Liquid lines may be installed level.

P. When brazing , remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Install pipe sleeves at penetrations in exterior walls and floor assemblies.

R. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping."

S. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

T. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

U. Seal pipe penetrations through exterior walls according to Division 07 Section "Joint Sealants" for materials and methods.

V. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC."

3.7 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

D. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

F. Welded Joints: Construct joints according to AWS D10.12/D10.12M.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.8 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for Piping and Equipment."

B. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
2. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
3. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
4. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.

E. Support multifloor vertical runs at least at each floor.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:
1. Comply with ASME B31.5, Chapter VI.

2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
   a. Fill system with nitrogen to the required test pressure.
   b. System shall maintain test pressure at the manifold gage throughout duration of test.
   c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
   d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.10 SYSTEM CHARGING

A. Charge system using the following procedures:
   1. Install core in filter dryers after leak test but before evacuation.
   2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
   3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
   4. Charge system with a new filter-dryer core in charging line.

3.11 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
   1. Open shutoff valves in condenser water circuit.
   2. Verify that compressor oil level is correct.
   3. Open compressor suction and discharge valves.
   4. Open refrigerant valves except bypass valves that are used for other purposes.
   5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following HVAC water-treatment systems:
   1. Closed hydronic hot water, chilled water and geothermal systems (both water and glycol).

1.2 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote control, signaling power-limited circuits.

1.3 PERFORMANCE REQUIREMENTS

A. Water Quality:
   1. General: Water used within HVAC systems shall minimize corrosion, scale buildup, and biological growth, to ensure optimum efficiency of HVAC equipment and that a hazard to either operating personnel or the environment has not been created.
   2. HVAC water treatment shall be based upon quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
   3. Water used within closed hydronic systems (both water and glycol), including hot-water heating, chilled water, geothermal, and dual-temperature water systems shall have the following qualities:
      a. Acidity (pH): 8.5 to 10.2.
      b. "P" Alkalinity: Record value and include in test report.
      c. Boron: Adjust value as needed to buffer pH to range indicated. Record final value in test report.
      d. Soluble Copper: 0.20 ppm, maximum.
      e. Conductivity: 3500 µS/cm, maximum.
      f. Free Caustic Alkalinity: 20 ppm, maximum.
      g. Microbiological Limits:
         1) Total Aerobic Plate Count: 1000 organisms/ml, maximum.
         2) Total Anaerobic Plate Count: 100 organisms/ml, maximum.
         3) Nitrate Reducers: 100organisms/ml, maximum.
         4) Sulfate Reducers: 0 organisms/ml.
         5) Iron Bacteria: 0 organisms/ml.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following products:
   1. Bypass feeders.
   2. Water meters.
   3. Inhibitor injection timers.
   4. Acidity (pH) controllers.
   5. TDS/conductivity controllers.
   6. Biocide feeder timers.
   7. Chemical solution tanks.
   8. Injection pumps.
   9. Chemical test equipment.
   10. Chemical materials.
   11. Water softeners.
   12. Multi-cartridge-type side stream filters.
   13. Centrifugal separators.
   14. Glycol test kit.
   15. Pressure Fill Systems.
   16. Glycol.

B. Shop Drawings: Submit shop drawings showing scaled plans, elevations, sections, and large-scale details. Include pretreatment and chemical treatment equipment, including tanks, sequence of operations and piping connections to HVAC systems, and clear space required for maintenance.
   1. Wiring Diagrams: For power and control wiring. Clearly differentiate between factory-installed and field-installed wiring.

C. Qualifications: For treatment provider and project technicians.

D. Reports:
   1. Water Quality Analysis: Submit copies of reports prepared by entity engaged to verify quality of water available at Site.
   2. Field Test Reports: Submit copies of field quality-control test reports.
   3. Startup Reports: Submit copies of reports documenting activities performed as part of startup operations and procedures. Submit copies of reports within two weeks of completion of startup operations and procedures.
   4. Training Reports: Submit copies of training reports documenting training dates and listing of attendees.

E. Operation and Maintenance Data: For sensors, injection pumps, water softeners, water filtration units, and controllers to include in maintenance manuals. Provide two weeks prior to training.

F. Water Treatment Program: Written explanation of procedures and operations to be performed, on an annual basis, by application equipment to ensure water quality criteria specified in Article "Performance Requirements" is achieved and maintained. Submit three copies in 3-ring binders.

G. Passivation Confirmation Letter (open condenser water systems): Submit a signed letter verifying passivation of galvanized-steel surfaces.

1.5 QUALITY ASSURANCE

A. Water Treatment Service Provider Qualifications: Engage a firm with not less than 5 years experience in the analysis and maintenance of the quality of water utilized in HVAC equipment and systems comparable to those indicated or required for the Project, and that clearly demonstrates a capability to accurately analyze water qualities, install water-treatment equipment, and apply water treatment processes as specified.
   1. Project Technicians: Certified Water Technologists (CWT) in good standing, certified by the AWT, or have similar training and experience qualifications.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service (all labor) program to maintain required water conditions and quality for chilled-water piping, heating hot-water piping, dual temperature-water piping, geothermal water piping, steam and condensate piping, condenser-water piping, and related equipment. Services and chemicals shall be provided for a period of one year from date of Preliminary Acceptance / Substantial Completion, and shall include the following:
   1. Initial water analysis (conducted at Site) and HVAC water-treatment recommendations. Written report of the findings to be left with the Owner and a copy of such report shall be forwarded to both the commissioning agent and consulting engineer.
   2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required glycol/chemical treatment prior to operation.
   3. Periodic field service and consultation. Include all work specified. Check for proper operation of all pumps, controllers, meters, and sensors. Calibrate sensors as required. Check chemical tank levels and inventory, and arrange chemical deliveries well in advance of needs.
   4. Customer report charts and log sheets.
   5. Laboratory technical analysis.
   6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.
   7. Train Owner’s operating personnel with the operation and adjustment of each piece of equipment / system, care and handling of treatment chemicals, and water test control procedures including basic water chemistry and the importance of water treatment.

1.7 WARRANTY

A. Written warranty, executed by manufacturer agreeing to repair or replace components or equipment that fail in materials or workmanship within warranty period indicated.
   1. Warranty Period: One year from date of Preliminary Acceptance / Substantial Completion or eighteen months from date of shipment from factory, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Earthwise Environmental.
2. H-O-H Chemicals, Inc.
3. Nalco Company.

2.2 MANUAL CHEMICAL-FEED EQUIPMENT (CLOSED PIPE SYSTEMS)

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
1. Capacity: 5 gallons.
2. Minimum Working Pressure: 125 psig.

2.3 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:
1. Type: AWWA C700, oscillating-piston, magnetic-drive, tantalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 150 psig.
4. Maximum Pressure Loss at Design Flow: 3 psig.
5. Registration: Gallons or cubic feet.
6. End Connections: Threaded or flanged.
7. Controls: Flow-control switches with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow. Hardwired to both the chemical controller and the building automation system (BAS).

B. Water Meter:
1. Type: AWWA C701, turbine-type, tantalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 150 psig.
4. Maximum Pressure Loss at Design Flow: 3 psig.
5. Registration: Gallons or cubic feet.
6. End Connections: Threaded or flanged.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow. Hardwired to both the chemical controller and the building automation system (BAS).

C. Chemical Solution Tanks:
1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: 120 gallons.

D. Chemical Solution Injection Pumps:
1. Self-priming, positive-displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

E. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints.
1. Provide stainless steel (ASTM A 269, Type 304) for steam boiler injection assemblies.

F. Pressure Fill System: Provide a complete factory packaged automatic glycol / make-up water fill system unit per system as manufactured by Bell and Gossett (GMU), Taco, or Armstrong. The unit shall consist of a base, 55 gallon tank (steel or polyethylene) with removable lid, fill vent opening, observable fluid level indicator scale (gallons), Y-strainers, isolation valves, triple combination shut off (non-slam check), calibrated balance valves, open drip proof motor, pump, expansion tank, motor contactor, pressure controls, interconnecting piping, low level safety shut down, remote alarm contacts, indicator light, fill valve

(automatic for water systems, manual for glycol systems), discharge pressure gauge, discharge line pressure reducing valve, isolation valves, pressure gauge, and single point power connection. Provide float type fill valve when used in non-glycol systems.

G. Injection Assembly:
1. Quill: Minimum NPS 1/2 with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Two-piece, stainless steel as described in "Stainless-Steel Pipes and Fittings" Article, and selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig at 200 deg F.

2.4 STAINLESS-STEEL PIPES AND FITTINGS

A. Stainless-Steel Tubing: Complying with ASTM A 269, Type 316.

B. Stainless-Steel Fittings: Complying with ASTM A 815/A 815M, Type 316, Grade WP-S.

C. Two-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball; carbon-filled TFE seats; threaded body design with adjustable stem packing; threaded ends; 250-psig SWP and 600-psig CWP ratings.

2.5 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounted cabinet for testing pH, conductivity, inhibitor, chloride, alkalinity, and hardness; include sulfite and testable polymer tests for high-pressure boilers, oxidizing biocide test for open cooling systems, glycol test kit for closed loop heating/cooling/dual temperature systems, and other test equipment as required by the water treatment supplier.

B. Portable Glycol Test Kit Assembly: Kit shall include sample container, chart, carrying case, instructions, all components required to determine the type of glycol, percent of glycol to water by volume, and condition of glycol (contamination) in the field.

C. Corrosion Test-Coupon Assembly: Constructed of 1-inch diameter corrosion resistant material, complete with piping, valves, 0-20 gpm flow meter and control valve, and mild steel and copper coupons. Alternatively, the assembly may be constructed from 1-inch black iron pipe, to provide additional surfaces for corrosion evaluation. The assembly shall be installed in the vertical plane, properly supported, with water flow from the bottom to the top of the assembly.
1. Two-station rack for closed-loop systems.
2. Four-station rack for open systems.

2.6 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer, compatible with piping system components and connected equipment, and capable of attaining water quality specified in "Performance Requirements" Article.

B. Glycol (Closed Systems):
1. Propylene Glycol: HVAC grade, containing corrosion inhibitors and environmental stabilizer additives for mixing with softened water. Softened water shall be used to dilute the glycol to 25 percent by volume in the system.
a. Industrial/automotive/marine/raw glycol shall NOT be used in any HVAC application.

2.7 FILTRATION EQUIPMENT

A. Multi-Cartridge (Minimum 4) Type Side Stream Filters (Closed Hydronic Systems):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. PEP Filters, Inc.
b. Cuno.
c. Watts.
2. Description: Floor-mounting housing with multiple filter cartridges (minimum 4) for removing particles from water.
a. Housing: Stainless steel; designed to separate inlet from outlet and to direct inlet through multiple cartridge-type water filters; with base, feet, or skirt.

1) Pipe Connections NPS 2 and Smaller: Threaded according to ASME B1.20.1.
2) Stainless Steel Housing Pipe Connections NPS 2-1/2 and Larger: Stainless Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
3) Tool free replacement of filters (V-Band Clamp, etc.).
4) Top vent with valve.
5) Bottom drain with valve.
6) Pressure and temperature taps across unit.

b. Multi-Filter Cartridges: Wound polypropylene media with a tin core, 0-20 micron rating, and a maximum temperature rating of 200 deg F; sized to properly fit the filter vessel. The minimum flow rate shall be the greatest of 5% of system pump flow rate/filtration of the entire system volume every 4 hours/25 GPM. Pressure drop through clean filters at flow rate above shall not exceed 2 psig. Filter cartridges shall be furnished in a quantity sufficient for six (6) complete changes of the filter vessel. Filter cartridges shall be changed when the pressure drop across the filter vessel exceeds 6 psi.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Site.

3.2 PREPARATION

A. Coordinate size and location of equipment indicated to be attached to concrete or masonry, and furnish anchoring devices with templates, diagrams, and instructions for their installation.

3.3 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are readily accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install water testing equipment on wall near water chemical application equipment.

C. Install interconnecting control wiring for chemical treatment controls and sensors.

D. Provide sensors and injectors in piping circuits. Coordinate locations with piping contractor.

E. Provide one portable glycol test kit assembly and instructions.

F. Provide 30% by volume inhibited glycol mix in all closed hydronic systems.
1. Glycol to be propylene for new systems or where propylene is currently used.
2. Glycol to be ethylene for existing systems where ethylene is currently installed.

G. Bypass Feeders: Install in all closed hydronic systems, and equipped with the following:
1. Install bypass feeder in a bypass circuit around circulating pumps.
2. Install water meter in makeup water supply.
3. Install test-coupon assembly in bypass circuit around circulating pumps.
4. Install a full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
5. Install a swing check on inlet after the isolation valve.

H. Multi-Cartridge Side Stream Filter: Install in all closed hydronic systems, and equipped with the following:
1. Install multi-cartridge side stream filter in a bypass circuit around circulating pumps.
2. Install a full-port ball isolation valves on inlet, outlet, vent and drain below feeder inlet.
3. Install a swing check on inlet after the isolation valve.
4. Install on 4-inch high equipment pad.

I. Install pressure fill units on all closed hydronic systems and include the following:
1. Install water meter in makeup water supply. Coordinate totalization signal with building automation system.
2. Coordinate alarm signal tie in to building automation system.
3. Provide pressure regulator set at the difference in height (in psig) between the discharge of the pressure regulator to the highest point in the system plus 5 psig.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings/details indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Refer to Division 23 Section "Basic HVAC Materials and Methods" for dielectric fittings.

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Refer to Division 23 Section "General-Duty Valves for HVAC Piping" for metal general-duty valves.

E. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.

F. Confirm applicable electrical requirements in Division 26 Sections for connecting electrical equipment.

G. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Division 26 Section "Conductors and Cables for Electrical Systems."

3.5 CLEANING

A. General: Prior to acceptance by the Owner, all grease, dirt, oil, and metallic oxides shall be removed from each closed recirculating and open cooling tower system. Each system in its entirety shall be cleaned (including all attached existing systems). Equipment shall be provided to meter the water, filter system water, mix and inject the cleaning solution into the system. Mechanical Contractor shall inform Water Treatment Contractor of all system materials of construction, to ensure chemical cleaner compatibility. Circulate cleaning agent, wetting all metal surfaces and flush from the system at completion. Supervision shall be provided by water treatment contractor.

B. Procedure:
1. Open all valves in a manner to ensure substantial flow through of all components of the system.
2. The system shall be filled through a suitable water meter to determine total water capacity, taking care to bleed all air.
3. Chemical liquid cleaner shall be added to the system in accordance with the chemical manufacturer’s requirements. The Chemical Water Treatment Contractor shall verify cleaner strength.
4. Hot Water Systems shall be heated to 160 - 180 deg F and circulated for 24 hours. Chilled Water/Geothermal Water Systems shall be circulated for 48 hours.
5. During the cleaning period, system water shall be circulated through the entire system. Where systems contain redundant pumps, both/all pumps shall operate at full speed to maximize velocity in the piping system. Mechanical Contractor / Chemical Treatment Contractor shall ensure that all small orifices (control valves, strainers, etc.) and branches remain free of debris. Utilize the system side stream filter or centrifugal separator for solids removal during the cleaning period. Filter media shall be changed as required. Provide additional filter cartridges beyond those specified for the cleaning process.
6. When the cleaning circulation period is complete, the system shall be drained and flushed with fresh water to remove the cleaning solution. Flushing shall continue until the fluid is clear and the total (M) alkalinity of the system water is within fifty (50) PPM of the total alkalinity of the make-up water. Once alkalinity is within stated parameters, clean all strainers. At that point a sampling of 10 locations throughout the system will be selected by the Owner’s representative (commissioning agent, engineer, or Architect). If the pipes at the selected locations flow at design flow free of debris and the fluid is clear, then cleaning will be deemed complete. If the flow is restricted in locations or the fluid is not clear, the cleaning process shall be repeated. Include provisions to clean the entire system three times. If the system is not clean after three rounds, notify the Owner’s representative (commissioning agent, engineer, or Architect) for further direction.
7. Immediately following completion and verification of flushing, certification records covering the cleaning operation shall be submitted to the Owner’s representative (commissioning agent, engineer, or Architect). Records shall include system volume, cleaner concentration, circulation time, volume of flush water, and final alkalinity reading.
8. When cleaning has been completed, each system shall then be chemically treated as specified. Each system must be filled immediately after cleaning, using chemically-treated water/glycol. All water/glycol added to any system after cleaning must be chemically treated.

C. Chemicals: Grease, dirt, oil and metallic oxides shall be removed from each closed and open water system using a non-foaming, liquid cleaning agent formulated to lift and disperse organic soil, and to chelate alkaline earth metals and metallic oxides. Chemicals shall be chosen so as not to damage any components of the systems.

D. Test Equipment: Provide one Test Cabinet with internal light, key cylinder lock, and acid resistant enamel finish, suitable for wall mounting. Cabinet shall be equipped with the necessary test sets for the determination of a complete water analysis, including, but not limited to, alkalinities, hardness, triple range conductivity meter, and all tests necessary to control chemical dosages.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
   2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water/glycol (as indicated), and are fully operational before introducing chemicals for water-treatment system.
   3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC system's startup procedures.
   4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
   5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
   7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
   8. Repair leaks and defects with new materials and retest piping until no leaks exist.
   9. Adjust water flow through corrosion coupon assemblies to equal a rate of 8 gpm = 3 ft./sec. through a 1-inch pipe, or lower flow as required by the Owner.

C. Remove and replace malfunctioning units and retest as specified.

D. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report advising the Owner of changes necessary to comply with the specified performance requirements for water quality. Sample boiler water at four-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality complying with performance requirements specified.

E. At one week intervals for five weeks following Preliminary Acceptance / Substantial Completion, perform separate water analysis on hydronic systems to show that automatic chemical-feed systems are maintaining water quality complying with performance requirements specified and prepare written report of findings, including changes necessary to ensure water quality is maintained in accordance with specified performance requirements. Submit copy of written reports to the Owner.

F. Comply with ASTM D 3370 and with the following standards:
   1. Silica: ASTM D 859.
   2. Steam System: ASTM D 1066.
   3. Acidity and Alkalinity: ASTM D 1067.
   4. Iron: ASTM D 1068.
   5. Water Hardness: ASTM D 1126.

3.7 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's designated maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment. Refer to Division 01 Section "Demonstration and Training."
   1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining the systems and equipment. The training will occur after the startup/cleaning report has been provided to the Owner and the trainer will provide two (2)

Installation and Operations manuals for the use of the Owner's personnel during training. Training shall be provided in two separate 4-hour sessions. Sessions shall not occur on the same day.

2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational troubleshooting. If the Installation and Operations Manual does not include a written troubleshooting guide one shall be provided.
3. Schedule training with the Owner, through Architect, with at least seven days' advance notice.

B. Demonstrate proper operation of equipment to commissioning agent or designated Owner personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements specified in Divisions 01 and 23.

END OF SECTION

METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus four (4)- inch wg to plus ten (10)-inch wg. Metal ducts include the following:
   1. Rectangular ducts and fittings.
   2. Single-wall, round**,** and flat-oval spiral-seam ducts and formed fittings.
   3. Double-wall, rectangular, round**,** and flat-oval spiral-seam ducts and formed fittings.

1.2 DEFINITIONS

A. Sealing Requirements Definitions: For the purposes of duct systems sealing requirements specified in this Section, the following definitions apply:
   1. Seams: A seam is defined as joining of two longitudinally (in the direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on the perimeter are deemed to be joints.
   2. Joints: Joints include girth joints; branch and sub-branch intersections; so-called duct collar tap-ins; fitting subsections; louver and air terminal connections to ducts; access door and access panel frames and jambs; duct, plenum, and casing abutments to building structures.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Hanger and Support Design: Hangers and supports shall comply with SMACNA’s “HVAC Duct Construction Standards – Metal and Flexible.”

1.4 SUBMITTALS

A. Shop Drawings: Drawn at a scale of not less than 1/4" = 1'-0". Show fabrication and installation details for metal ducts.
   1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
   2. Duct layout indicating sizes and pressure classes.
   3. Elevations of top and bottom of ducts.
   4. Dimensions of main duct runs from building grid lines.
   5. Fittings.
   6. Reinforcement and spacing.
   7. Seam and joint construction.
   8. Penetrations through fire-rated and other partitions.
   9. Equipment installation based on equipment being used on Project.
   10. Duct accessories, including access doors and panels.
   11. Hangers and supports, including methods for duct and building attachment and vibration isolation.

B. Delegated-Design Submittal:
   1. Spacing of hangers and supports.
   2. Design calculations: Calculations, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Other systems installed in same space as ducts.
   3. Ceiling- and wall-mounting access doors and panels required to provide access to dampers and other operating devices.
   4. Ceiling-mounting items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

C. Comply with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations," Ch. 3, "Duct System," for range hood ducts, unless otherwise indicated.

1.6 DELIVERY, STORAGE AND HANDLING

A. All materials shall be stored in a designated area and protected from inclement weather.

B. All materials shall be secured so as not to be a hazard during the construction process.

C. Store ductwork with tight-fitting seals on open ends to ensure ductwork is free of all dirt, debris and moisture during the installation process.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. PVC-Coated Galvanized Steel: Acceptable by authorities having jurisdiction for use in fabricating ducts with UL 181, Class 1 listing. Lock-forming-quality, galvanized sheet steel complying with ASTM A 653/A 653M and having G90 coating designation. Factory-applied PVC coatings shall be 4 mils thick on sheet metal surfaces of ducts and fittings exposed to corrosive conditions and 2 mils thick on opposite surfaces.

D. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.

E. Stainless Steel: ASTM A 480/A 480M, Type 304 and 316.

F. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

G. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

H. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

I. Insulated Flexible Ducts: Flexible ducts wrapped with flexible glass fiber insulation, enclosed by seamless aluminum pigmented plastic vapor barrier jacket; maximum 0.23 K value at 75 degrees F.

2.2 SEALANT MATERIALS

A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes combinations of open-weave fabric strips and mastics.

B. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

C. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

D. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.3 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

B. Hanger Materials: Galvanized sheet steel or threaded steel rod.

1. Hangers Installed in Corrosive Atmospheres: All-thread rods used in pool areas, pool equipment rooms, and pool supporting spaces shall be aluminum if the ducts are aluminum and stainless steel if the ducts are stainless steel.
2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
3. Supports for Aluminum Ducts: Aluminum support materials..

2.4 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.

C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.
1. Duct Size: Maximum 30 inches wide and up to 2-inch wg pressure class.
2. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.

D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of nonbraced panel area unless ducts are lined.

2.5 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

A. Manufacturers: applicable to factory-fabricated duct and fittings:

B. Subject to compliance with requirements, provide products by one of the following manufacturers:
1. Ductmate Industries, Inc.
2. Lindab.
3. Lockformer.
4. McGill Airflow.
5. Nexus Inc.
6. Semco, Inc.
7. Ward Industries.

C. Diameter as applied to flat-oval ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.

D. Round, Longitudinal- and Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

E. Flat-Oval, Longitudinal- and Spiral Lock-Seam Ducts: Fabricate supply ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible. Fabricate ducts larger than 72 inches in diameter with butt-welded longitudinal seams.

F. Duct Joints:
1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.

3. Ducts Larger Than 72 Inches in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards--Metal and Flexible," Figure 3-2.
4. Round Ducts: Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer's tolerances.
5. Flat-Oval Ducts: Prefabricated connection system consisting of two flanges and one synthetic rubber gasket.

G. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.

H. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

I. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg:
   a. Ducts 3 to 36 Inches in Diameter: 0.034 inch.
   b. Ducts 37 to 50 Inches in Diameter: 0.040 inch.
   c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.
   d. Ducts 62 to 84 Inches in Diameter: 0.064 inch.
3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg:
   a. Ducts 3 to 26 Inches in Diameter: 0.034 inch.
   b. Ducts 27 to 50 Inches in Diameter: 0.040 inch.
   c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.
   d. Ducts 62 to 84 Inches in Diameter: 0.064 inch.
4. Flat-Oval Mitered Elbows: Welded construction with same metal thickness as longitudinal-seam flat-oval duct.
5. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
6. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
7. Round Elbows 9 through 14 Inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
8. Round Elbows Larger Than 14 Inches in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
9. Die-Formed Elbows for Sizes through 8 Inches in Diameter and All Pressures 0.040 inch thick with 2-piece welded construction.
10. Flat-Oval Elbow Metal Thickness: Same as longitudinal-seam flat-oval duct specified above.
11. Pleated Elbows for Sizes through 14 Inches in Diameter and Pressures through 10-Inch wg: 0.022 inch.

J. PVC-Coated Elbows and Fittings: Fabricate elbows and fittings as follows:
1. Round Elbows 4 to 8 Inches in Diameter: Two piece, die stamped, with longitudinal seams spot welded, bonded, and painted with PVC aerosol spray.
2. Round Elbows 9 to 26 Inches in Diameter: Standing-seam construction.
3. Round Elbows 28 to 60 Inches in Diameter: Standard gored construction, riveted and bonded.
4. Other Fittings: Riveted and bonded joints.
5. Couplings: Slip-joint construction with a minimum 2-inch insertion length.

2.6 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. Manufacturers: applicable to factory-fabricated duct and fittings.: Subject to compliance with requirements, provide products by one of the following manufacturers:
   1. McGill AirFlow LLC.
   2. Sheet Metal Connectors, Inc.

B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

C. Outer Duct: 304 stainless steel (outdoor application) / G90 galvanized steel (indoor application) complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, “Fibrous Glass Duct Liner Standard.”
   1. Maximum “R” Value: R = 5.0 for interior ducts, R = 8.0 for exterior ducts.
   2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
   3. Coat insulation with antimicrobial coating.

G. Inner Duct: Minimum 0.028-inch solid sheet steel.

H. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Traverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

I. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.7 DOUBLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. Manufacturers: applicable to factory-fabricated duct and fittings.: Subject to compliance with requirements, provide products by one of the following manufacturers:
   1. Lindab Inc.
   2. McGill AirFlow LLC.
   3. SEMCO Incorporated.
   4. Sheet Metal Connectors, Inc.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

C. Outer Duct: 304 stainless steel (outdoor application) / G90 galvanized steel (indoor application) complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
   1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
      a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
   2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

a. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
b. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Inner Duct: Minimum 0.028-inch solid sheet steel.

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, “Fibrous Glass Duct Liner Standard.”
1. Maximum ”R” Value: R = 5.0 for interior ducts., R = 8.0 for exterior ducts.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
1. Supply Ducts (constant volume units): +2".
2. Supply Ducts (before Air Terminal Units): +4”.
3. Supply Ducts (after Air Terminal Units): +2”.
4. Supply Ducts (between fan and first system fire damper): +8”.
5. Return Ducts (Negative Pressure): -2”.
6. Return Ducts (between nearest fire damper and return fan inlet): -4”.
7. Return Ducts (return fan discharge and AHU intake / exhaust damper): -4”.
8. Exhaust Ducts (Negative Pressure): -2”.

B. All ducts shall be galvanized steel except as follows:
1. Locker room / shower room / green house ducts:
a. Aluminum or PVC coated galvanized steel, with seams and laps arranged on top of duct.
2. Exposed Supply Ducts In Occupied Spaces (Gymnasiums / Wrestling / Fitness / Multipurpose / Cafetorium / Library / etc.):
a. Spiral round/oval galvanized sheet steel with paint grip finish.
3. Underground Ducts: Concrete-encased (2” thick minimum) PVC-coated galvanized steel with thicker coating on duct exterior.

3.2 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

B. Install round and flat-oval ducts in lengths not less than 12 feet unless interrupted by fittings.

C. Install ducts with fewest possible joints.

D. Install fabricated fittings for changes in directions, size, and shape and for connections.

E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.

F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

J. Coordinate layout with suspended ceiling, fire- and control dampers, lighting layouts, and similar finished work.

K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

L. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 23 Section "Air Duct Accessories." Firestopping materials and installation methods are specified in Division 07.

O. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.3 PVC-COATED DUCT, SPECIAL INSTALLATION REQUIREMENTS

A. Repair damage to PVC coating with manufacturer's recommended materials.

3.4 UNDERSLAB DUCTS, SPECIAL INSTALLATION REQUIREMENTS

A. Verify undamaged condition of ducts before enclosure with fill or encasement.

B. Protect ducts from damage by equipment used in placing fill materials and concrete on or around ducts.

C. Protect duct openings from damage and prevent entrance of foreign materials.

3.5 SEAM AND JOINT SEALING

A. Seal all duct seams and joints to the most severe requirement between the latest Chicago Building Code and SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.

B. Utilize sealant designed for outdoor use with ductwork exposed to the outdoors.

C. Seal ducts before external insulation is applied.

3.6 HANGING AND SUPPORTING

A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.

B. Support vertical ducts at maximum intervals of 16 feet and at each floor.

C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

D. For concrete structure installations: Install concrete inserts before placing concrete.

E. For concrete structure installations: Install powder-actuated concrete fasteners after concrete is placed and completely cured.

1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

3.7 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Division 23 Section "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.8 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:

1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
3. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round and flat-oval ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2-inch wg (both positive and negative pressures), and Leakage Class 6 for pressure classes from 2- to 10-inch wg.
4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

END OF SECTION

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:
1. Backdraft dampers.
2. Volume dampers.
3. Fire dampers.
4. Duct silencers.
5. Turning vanes.
6. Duct-mounting access doors.
7. Flexible connectors.
8. Flexible ducts.
9. Duct accessory hardware.

1.2 SUBMITTALS

A. Product Data: For the following:
1. Backdraft dampers.
2. Volume dampers.
3. Fire dampers.
4. Duct silencers.
5. Turning vanes.
6. Duct-mounting access doors.
7. Flexible connectors.
8. Flexible ducts.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
1. Special fittings.
2. Backdraft dampers.
3. Manual-volume damper installations.
4. Motorized-control damper installations.
5. Fire-damper and combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.
6. Duct silencers.
7. Duct mounted access doors.
8. Flexible connectors.
9. Flexible ducts.
10. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

1.3 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

1.4 DELIVERY, STORAGE AND HANDLING

A. Materials delivered to the site must be coordinated with the site supervisor prior to delivery.

B. All materials shall be stored in a designated area and protected from the environment.

C. All materials shall be secured so as not to be a hazard during the construction process.

D. All materials must be free of all dirt, debris and moisture during the installation process.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following manufacturers:

1. Backdraft Dampers:
   a. Greenheck.
   b. Ruskin.
   c. Vent Products Company.
2. Volume Dampers
   a. Nailor.
   b. Ruskin.
   c. Vent Products Company.
   d. Pottorff.
3. Fire Dampers:
   a. Greenheck.
   b. Ruskin.
   c. Vent Products Company.
   d. Pottorff.
4. Duct Silencers:
   a. Industrial Acoustics Co. (IAC).
   b. Ruskin.
   c. Vibro-Acoustics.
   d. Price.
5. Duct-Mounting Access Doors:
   a. CESCO Products.
   b. Ductmate Industries.
   c. Greenheck.
   d. Pottorff.
6. Flexible Connectors:
   a. Ductmate Industries.
   b. Ventfabrics, Inc.
   c. Ward Industries.
7. Flexible Ducts:
   a. Flexmaster USA.
   b. Hart and Cooley, Inc.
   c. McGill Airflow Corp.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless Steel: ASTM A 480/A 480M Type 304 (specify Type 314 as required by the application).

D. Aluminum Sheets: ASTM B 209 alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: ASTM B 221, alloy 6063, temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT DAMPERS

A. Description: Multiple-blade, parallel action gravity balanced, with center-pivoted blades of maximum 6-inch width, with sealed edges, assembled in rattle-free manner with 90-degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.

B. Frame: 0.063-inch thick extruded aluminum, with welded corners and mounting flange.

C. Blades: 0.050-inch thick aluminum sheet.

D. Blade Seals: Neoprene.

E. Blade Axles: Galvanized steel.

F. Tie Bars and Brackets: Galvanized steel.

G. Return Spring: Adjustable tension.

2.4 VOLUME DAMPERS

A. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.
   1. Pressure Classes of 3-Inch wg or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.

B. Standard Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, with linkage outside airstream and suitable for horizontal or vertical applications.
   1. Steel Frames (For use in steel ductwork): Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
   2. Roll-Formed Steel Blades (For use with steel frames): 0.064-inch- thick, galvanized sheet steel.
   3. Aluminum Frames (For use in stainless steel or aluminum ductwork): Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
   4. Roll-Formed Aluminum Blades (For use with aluminum frames): 0.10-inch- thick aluminum sheet.
   5. Extruded-Aluminum Blades (For use with aluminum frames): 0.050-inch- thick extruded aluminum.
   6. Blade Axles: Galvanized steel. Drive shaft will be the full length of the blade.
   7. Bearings: Stainless-steel sleeve.
   8. Tie Bars and Brackets: Aluminum (aluminum or stainless steel ductwork applications), Galvanized steel (galvanized steel ductwork applications).

C. Low-Leakage Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
   1. Steel Frames (For use in steel ductwork) : galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
   2. Roll-Formed Steel Blades (For use with steel frames): 0.064-inch- thick, galvanized sheet steel.
   3. Aluminum Frames (For use in stainless steel or aluminum ductwork) : 0.10-inch- thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
   4. Roll-Formed Aluminum Blades (For use with aluminum frames): 0.10-inch- thick aluminum sheet.
   5. Extruded-Aluminum Blades (For use with aluminum frames): 0.050-inch- thick extruded aluminum.
   6. Blade Axles: Galvanized steel. Drive shaft will be the full length of the blade.
   7. Bearings: Stainless-steel sleeve thrust or ball.
   8. Blade Seals: Neoprene.
   9. Jamb Seals: Cambered stainless steel.
   10. Tie Bars and Brackets: Aluminum (aluminum or stainless steel ductwork applications), Galvanized steel (galvanized steel ductwork applications).

D. Jackshaft: 1-inch- diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
   1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.

E. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

F. FIRE DAMPERS

G. Fire dampers shall be labeled according to UL 555.

H. Fire Rating: Insert rating as required by application hours.

I. Frame: Curtain type with blades outside airstream fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

J. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
   1. Minimum Thickness: 0.052 or 0.138 inch thick as indicated and of length to suit application.
   2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.

K. Mounting Orientation: Vertical or horizontal as indicated.

L. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

M. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

N. Fusible Links: Replaceable, 165 deg F rated.

2.5 DUCT SILENCERS

A. General Description: Factory-fabricated and -tested, round or rectangular silencers with performance characteristics and physical requirements as indicated.

B. Fire Performance: Adhesives, sealants, packing materials, and accessory materials shall have fire ratings not exceeding 25 for flame-spread index and 50 for smoke-developed index when tested according to ASTM E 84.

C. Rectangular Units: Fabricate casings with a minimum of 0.034-inch- thick, solid galvanized sheet metal for outer casing and 0.022-inch- thick, ASTM A 653/A 653M, G90perforated galvanized sheet metal for inner casing.

D. Round Units:
   1. Outer Casings:
      a. ASTM A 653/A 653M, G90 galvanized sheet steel.
      b. Up to 24 Inches in Diameter: 0.034 inch thick.
      c. 26 through 40 Inches in Diameter: 0.040 inch thick.
      d. 42 through 52 Inches in Diameter: 0.052 inch thick.
      e. 54 through 60 Inches in Diameter: 0.064 inch thick.
      f. Casings fabricated of spiral lock-seam duct may be one size thinner than that indicated.
   2. Interior Casing, Partitions, and Baffles:
      a. ASTM A 653/A 653M, G90, galvanized sheet steel.
      b. At least 0.034 inch thick and designed for minimum aerodynamic losses.

E. Sheet Metal Perforations: 1/8-inch diameter for inner casing and baffle sheet metal.

F. Fill Material: Moisture-proof nonfibrous material. Provide mylar or tedlar cover over fill material. Fill material shall not be exposed to the airstream.
   1. Erosion Barrier: Polymer bag enclosing fill and heat-sealed before assembly.

G. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations.
   1. Do not use nuts, bolts, or sheet metal screws for unit assemblies.
   2. Lock form and seal or continuously weld joints.
   3. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
   4. Reinforcement: Cross or trapeze angles for rigid suspension.

H. Source Quality Control:
   1. Acoustic Performance: Test according to ASTM E 477.
   2. Record acoustic ratings, including dynamic insertion loss and self-noise power levels with an airflow of at least 2000-fpm face velocity.
   3. Leak Test: Test units for air tightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

AIR DUCT ACCESSORIES

2.6 TURNING VANES

A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate 1-1/2-inch- wide, single-vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.

C. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.7 DUCT-MOUNTING ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include piano hinge and cam latches.
   1. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
   2. Provide number of hinges and locks as follows:
      a. Less than 12 Inches Square: Secure with two sash locks.
      b. Up to 18 Inches Square: Continuous hinge and two sash locks.
      c. Larger than 18 inches square: Continuous hinge and two compression latches with outside and inside handles.

C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches.
   1. Frame: Galvanized sheet steel, with spin-in notched frame.

D. Pressure Relief Access Door: Double wall and duct mounting; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated, latches, and retaining chain.
   1. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

E. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

F. Insulation: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.8 FLEXIBLE CONNECTORS

A. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

B. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Select metal compatible with ducts.

C. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
   1. Minimum Weight: 26 oz./sq. yd..
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.

D. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
   1. Minimum Weight: 24 oz./sq. yd..
   2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
   3. Service Temperature: Minus 50 to plus 250 deg F.

2.9 FLEXIBLE DUCTS

A. Insulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor barrier film.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   2. Maximum Air Velocity: 4000 fpm.
   3. Temperature Range: Minus 10 to plus 160 deg F

B. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 through 18 inches to suit duct size.

2.10 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

D. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.

E. Provide test holes at fan inlets and outlets and elsewhere as indicated.

F. Install fire dampers, with fusible links, according to manufacturer's UL-approved written instructions.

G. Install duct silencers rigidly to ducts.

H. Install duct access doors to allow for inspecting, adjusting, and maintaining duct accessories, control devices - sensors and terminal units as follows:
   1. On both sides of duct coils. On terminal units coordinate upstream coil access door with equipment supplier.
   2. Downstream from volume dampers, turning vanes, and duct mounted equipment.
   3. Adjacent to fire dampers, providing access to reset or reinstall fusible links.
   4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.
   5. On sides of ducts where adequate clearance is available.
   6. Where indicated on plans.
   7. Upstream and downstream of ducted fans.

I. Label access doors according to Division 23 Section "Identification for HVAC."

J. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

K. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

L. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

M. Connect diffusers or light troffer boots to low pressure ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

N. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.

O. Install duct test holes where indicated and required for testing and balancing purposes.

P. Provide turning vanes in all short radius / square elbows (>45 degrees) and tees.

3.2 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire dampers for proper action.

C. Final positioning of manual-volume dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.3 DEMONSTRATION AND COMMISSIONING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the duct accessories.
   1. Train Owner's maintenance personnel on troubleshooting, servicing, and maintaining duct accessories. The training will occur after all devices are installed including all access doors. The trainer will provide two (2) Installation and Operations manuals for the use of the owners personnel during training.
   2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational trouble shooting. If the IOM does not include a written trouble shooting guide one will be provided.
   3. Schedule training with Owner, through Architect, with at least seven days' advance notice.
   4. Training will occur in one (1) two (2) hour session and will include the dropping and resetting of 3 fire dampers selected by the owner. This portion of the training may not take longer than 30 minutes of the training session.

B. Demonstrate proper operation of equipment to commissioning agent or designated owners personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements in Division 01 or 23.
   1. For all fire dampers or access doors for fire dampers installed on this project the Contractor will demonstrate that any fire dampers selected by the owner can be dropped and reset using the provided access doors.

END OF SECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:
1. Utility set fans.
2. Centrifugal roof ventilators.
3. Upblast propeller roof exhaust fans.
4. Centrifugal wall ventilators.
5. In-line centrifugal fans.

1.2 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Provide wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

D. Field Quality-Control Test Reports: Submit reports documenting the activities required to be performed in PART 3. These reports are to be submitted two weeks after the startup is completed.

E. Training Reports: Submit reports on training documenting dates and attendance.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.5 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on sea level.

B. Operating Limits: Classify according to AMCA 99.

1.6 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.7 EXTRA MATERIALS

A. Furnish one set of belts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide diffusers by one of the following:
   1. Utility Set Fans:
      a. Greenheck.
      b. Loren Cook Company.
      c. Penn Ventilation.
   2. Centrifugal Roof Ventilators:
      a. Greenheck.
      b. Loren Cook Company.
      c. Penn Ventilation.
   3. Upblast Propeller Roof Exhaust Fans:
      a. Greenheck.
      b. Loren Cook Company.
      c. Penn Ventilation.
      d. Twin City.
   4. Centrifugal Wall Ventilators:
      a. Greenheck.
      b. Loren Cook Company.
      c. Penn Ventilation.
   5. In-line Centrifugal Fans:
      a. Greenheck.
      b. Loren Cook Company.
      c. Penn Ventilation.

2.2 UTILITY SET FANS

A. Description: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.

B. Housing: Fabricated of steel with side sheets fastened with a deep lock seam or welded to scroll sheets. Housing discharge arrangement shall be adjustable to eight standard positions.

C. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.
   1. Blade Materials: Steel.
   2. Blade Type: Backward inclined or forward curved.

D. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

E. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L_{50} of 200,000 hours.

F. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   1. Service Factor Based on Fan Motor Size: 1.5.
   2. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
   3. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   4. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

G. Accessories:
   1. Back draft Dampers: Gravity actuated with counterweight and interlocking aluminum blades with felt edges in steel frame installed on fan discharge.
   2. Access Door: Gasketed door in scroll with latch-type handles.
   3. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
   4. Inlet Screens: Removable wire mesh.
   5. Drain Connections: NPS 3/4 threaded coupling drain connection installed at lowest point of housing.
   6. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.

2.3 CENTRIFUGAL ROOF VENTILATORS

A. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
   1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt-Driven Drive Assembly (Provide direct drive for all units less then ½ HP): Resiliently mounted to housing, with the following features:
   1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
   3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
   4. Fan and motor isolated from exhaust airstream.

E. Accessories:
   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
   3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
   4. Dampers (Fans less then 3000 CFM): Counterbalanced, parallel-blade, back draft dampers mounted in curb base; factory set to close when fan stops.
   5. Motorized Dampers (Fans 3000 CFM and higher): Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
   6. Specify roof curbs, if they are site fabricated, in Division 07 Section "Roof Accessories." Retain paragraph and subparagraphs below to require roof curbs to be provided by fan manufacturer.

F. Roof Curbs: Galvanized steel; mitered and welded corners; 2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 2-inch wood nailer. Size as required to suit roof opening and fan base.

2.4 UPBLAST PROPELLER ROOF EXHAUST FANS

A. Description: Direct- or belt-driven propeller fans consisting of housing, wheel, butterfly-type discharge damper, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

B. Wind Band, Fan Housing, and Base: Reinforced and braced aluminum, containing aluminum butterfly dampers and rain trough, motor and drive assembly, and fan wheel.
   1. Damper Rods: Steel with bronze bearings.

C. Fan Wheel: Replaceable, cast-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

D. Belt-Driven Drive Assembly (Provide direct drive units for all units less then ½ HP): Resiliently mounted to housing; weatherproof housing of same material as fan housing with the following features:
   1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   2. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings.
   3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
   4. Motor Mount: On outside of fan cabinet, adjustable base for belt tensioning.

E. Roof Curbs: Galvanized steel; mitered and welded corners; 2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 2-inch wood nailer. Size as required to suit roof opening and fan base.

2.5 CENTRIFUGAL WALL VENTILATORS

A. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.

B. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.

C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.

D. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
   1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
4. Fan and motor isolated from exhaust airstream.

E. Accessories:
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
4. Wall Grille: Ring type for flush mounting.
5. Dampers: Counterbalanced, parallel-blade, back draft dampers mounted in wall sleeve; factory set to close when fan stops.

2.6 IN-LINE CENTRIFUGAL FANS

A. Description: In-line, belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing[; with wheel, inlet cone, and motor on swing-out service door].

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

F. Accessories:
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
3. Companion Flanges: For inlet and outlet duct connections.
4. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.

2.7 MOTORS

A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

B. Enclosure Type: Totally enclosed, fan cooled.

2.8 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using spring isolators having a static deflection of 1 inch.
1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounting units on concrete bases.

D. Secure roof-mounting fans to roof curbs with cadmium-plated hardware

E. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

F. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch.

G. Install units with clearances for service and maintenance.

H. Label units according to requirements specified in Division 23 Section "Identification for HVAC."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Conductors and Cables for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

B. Review data in the operation and maintenance manuals. Refer to Division 01 Section "Contract Closeout."

C. Schedule training with Owner, through Architect, with at least 7 days' advance notice.

D. Demonstrate operation of power ventilators. Conduct walking tour of the Project. Briefly identify location and describe function, operation, and maintenance of each power ventilator.

3.5 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

3.6 CLEANING

A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Clean fan interiors to remove foreign material and construction debris. Vacuum clean fan wheel and cabinet.

3.7 CONTRACTOR STARTUP AND REPORTING

A. Final Checks before Startup: Perform the following operations and checks before startup. Startup service includes the testing, inspections and startup test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections for piping, ducts, and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnects.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in the fully open position.
7. Disable automatic temperature-control operators.

B. Starting procedures for fans are as follows:
1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.
2. Measure and record motor voltage and amperage.

C. Shut unit down and reconnect automatic temperature-control operators.

D. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for procedures for air-handling-system testing, adjusting, and balancing.

E. Replace fan and motor pulleys as required to achieve design conditions.

3.8 DEMONSTRATION AND COMMISSIONING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the fans.

1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining chillers. The training will occur after the startup report has been provided to the owner and the trainer will provide two (2) Installation and Operations manuals for the use of the owner’s personnel during training.
2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational trouble shooting. If the IOM does not include a written trouble shooting guide one will be provided.
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

B. Demonstrate proper operation of equipment to commissioning agent or designated owners personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements in Division 01 and 23.

END OF SECTION

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

1.2 DEFINITIONS

A. Diffuser: Circular, square, or rectangular air distribution outlet, generally located in the ceiling and comprised of deflecting members discharging supply air in various directions and planes and arranged to promote mixing of primary air with secondary room air.

B. Grille: A louvered or perforated covering for an opening in an air passage, which can be located in a sidewall, ceiling, or floor.

C. Register: A combination grille and damper assembly over an air opening.

1.3 SUBMITTALS

A. Product Data: For each product indicated, include the following:
   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   5. Duct access panels.

1.4 QUALITY ASSURANCE

A. ARI Compliance: Test and rate diffusers, registers, and grilles in accordance with ARI 650 "Standard for Diffusers, registers, and grilles".

B. ASHRAE Compliance: Test and rate diffusers, registers, and grilles in accordance with ASHRAE 70 "Method of Testing for Rating the Air Flow Performance of Outlets and Inlets".

C. ADC Compliance: Test and rate diffusers, registers, and grilles in certified laboratories under requirements of ADC 1062 "Certification, Rating and Test Manual".

D. ADC Seal: Provide diffusers, registers, and grilles bearing ADC Certified Rating Seal.

E. NFPA Compliance: Install diffusers, registers, and grilles in accordance with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver diffusers, registers, and grilles wrapped in factory-fabricated fiber- board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.

B. Store diffusers, registers, and grilles in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

1.6 WARRANTY

A. Provide warranty on materials and labor for 18 months starting from date of delivery, or one year from date of substantial completion, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide diffusers by one of the following:

1. Ceiling Air Diffusers:
   a. Nailor.
   b. Titus Products Div.; Philips Industries, Inc.
   c. Price Industries.
2. Wall Registers and Grilles
   a. Nailor.
   b. Titus Products Div.; Philips Industries, Inc.
   c. Price Industries.

2.2 CEILING AIR DIFFUSERS

A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.

D. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as listed on diffuser schedule.

2.3 WALL REGISTERS AND GRILLES

A. General: Except as otherwise indicated, provide manufacturer's standard wall registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide wall registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Wall Compatibility: Provide registers and grilles with border styles that are compatible with adjacent wall systems, and that are specifically manufactured to fit into wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of wall construction which will contain each type of wall register and grille.

D. Types: Provide wall registers and grilles of type, capacity, and with accessories and finishes as listed on schedule.

2.4 DOOR AND TRANSFER GRILLES

A. General: Except as otherwise indicated, provide manufacturer's standard wall registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide wall registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Construction: Outer borders shall be constructed of heavy extruded aluminum and shall have countersunk screw holes for a neat appearance. Border shall be interlocked at the four corners and mechanically staked to form a rigid frame. Extruded aluminum inverted V-blades with a deflection shall be used to create a sight proof design and provide additional stiffness to the grille.

D. Types: Provide wall grilles of type, capacity, and with accessories and finishes as listed on schedule.

2.5 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

DIFFUSERS, REGISTERS, AND GRILLES

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 CLEANING

A. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

3.4 CONTRACTOR STARTUP AND REPORTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:
   1. Listed double-wall vents, chimneys.

1.2 SUBMITTALS

A. Product Data: For the following:
   1. Type B and BW vents.
   2. Special gas vents.
   3. Building-heating-appliance and generator chimneys.
   4. Guy wires and connectors.

B. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.
   2. For installed products indicated to comply with design loads, include calculations required for selecting restraints and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Welding certificates.

D. Calculations: Provide computer calculation for flue sizing based on actual installed equipment at operating temperature, routing and sizing for each flue. Calculation shall include all inputs and a sketch indicating all lengths, fittings and sizes used. Calculation shall be stamped by a licensed professional engineer in the state of Illinois.

E. Warranty: Special warranty specified in this Section.

1.3 QUALITY ASSURANCE

A. Source Limitations: Obtain listed system components through one source from a single manufacturer.

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.

C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.4 DELIVERY, STORAGE AND HANDLING

A. Store products as recommended by manufacturer.

1.5 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories.".

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.
   1. Warranty Period: 10 years from date of Preliminary Acceptance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:
   1. Listed Type B And BW Vents
      a. Heat-Fab, Inc.
      b. Metal-Fab, Inc.
      c. Schebler Co. (The).

d. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
e. Van-Packer Company, Inc.

2. Listed Special Gas Vents (Condensing Boiler/Water Heater Applications)
   a. Heat-Fab, Inc.
   b. Metal-Fab, Inc.
   c. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
   d. Schebler.
3. Listed Building-Heating-Appliance and Generator Chimneys (All Forced Draft / Fan Assisted Equipment and Generators)
   a. Heat-Fab, Inc.
   b. Metal-Fab, Inc.
   c. Schebler Co. (The).
   d. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
   e. Van-Packer Company, Inc.

2.2 LISTED TYPE B AND BW VENTS (ATOMOSPHERIC FIRED APPLIANCES ONLY)

A. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F continuously for Type B, or 550 deg F continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.

B. Construction: Inner shell and outer jacket separated by at least a 1/4-inch airspace.

C. Inner Shell: ASTM B 209, Type 1100 aluminum or ASTM B 209, Type 3003 aluminum or ASTM B 209, Type 3105 aluminum.

D. Outer Jacket: Galvanized steel.

E. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, fire stop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Termination type shall be one of the following or as indicated on project details:
   1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
   2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
   3. Termination: Exit cone with drain section incorporated into riser.
   4. Termination: Antibackdraft.

2.3 LISTED SPECIAL GAS VENTS (CONDENSING BOILER/WATER HEATER APPLICATIONS)

A. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F continuously, with positive or negative flue pressure complying with NFPA 211.

B. Construction: Inner shell and outer jacket separated by at least a 1/2-inch airspace.

C. Inner Shell: ASTM A 959, Type AL 29-4C stainless steel.

D. Outer Jacket: Stainless steel.

E. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, fire stop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Termination type shall be one of the following or as indicated in the project details:
   1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
   2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
   3. Termination: Exit cone with drain section incorporated into riser.

2.4 LISTED BUILDING-HEATING-APPLIANCE and GENERATOR CHIMNEYS (ALL FORCED DRAFT / FAN ASSISTED EQUIPMENT AND GENERATORS)

A. Description (Boiler/Water Heater): Double-wall metal vents tested according to UL 103 and rated for 1000 deg F continuously, or 1700 deg F for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.

B. Construction (Boiler/Water Heater): Inner shell and outer jacket separated by at least a 1-inch annular space. Fill annular space with high-temperature, ceramic-fiber insulation on renovation projects only in which routing is through existing chase/soffits or attics..

C. Inner Shell (Boiler/Water Heater): ASTM A 666, Type 304 stainless steel.

D. Description (Generator Engine Exhaust): Double-wall metal vents tested according to UL 103 and UL 959 and rated for 1400 deg F continuously, or 1800 deg F for 10 minutes; with positive or negative flue pressure complying with NFPA 211.

E. Construction (Generator Engine Exhaust): Inner shell and outer jacket separated by at least a 3-inch annular space filled with high-temperature, ceramic-fiber insulation.

F. Inner Shell (Generator Engine Exhaust): ASTM A 666, Type 304 stainless steel.

G. Outer Jacket: Galvanized steel.

H. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, fire stop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Provide one of the following terminations or as indicated on project details:
   1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
   2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
   3. Termination: Exit cone with drain section incorporated into riser.

2.5 GUYING AND BRACING MATERIALS (CHIMNEYS/VENTS/FLUES EXTENDING MORE THEN 6 FEET ABOVE THE ROOF)

A. Cable: Minimum four galvanized, stranded wires (final quantity as recommended by chimney/stack/flue vent manufacturer for project specific application) of the following thickness:
   1. Minimum Size: 1/4 inch in diameter.
   2. For ID Sizes 4 to 15 Inches: 5/16 inch.
   3. For ID Sizes 18 to 24 Inches: 3/8 inch.
   4. For ID Sizes 27 to 30 Inches: 7/16 inch.
   5. For ID Sizes 33 to 36 Inches: 1/2 inch.
   6. For ID Sizes 39 to 48 Inches: 9/16 inch.

B. Pipe: Minimum three galvanized steel, NPS 1-1/4.

C. Angle Iron: Minimum three galvanized steel, 2 by 2 by 0.25 inch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.
   1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

A. Listed Type B and BW Vents: Vents for certified gas appliances (Atmospheric Fired Appliances Only). .

B. Listed Special Gas Vent: Condensing gas appliances.

C. Listed Building-Heating-Appliance Chimneys: Forced draft/fan assisted boilers, water heaters, and exhaust for engines.

D. Listed Building-Heating-Appliance Chimneys: exhaust for engines.

3.3 INSTALLATION OF LISTED VENTS AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading. Where maximum unsupported lengths of stack are exceeded, support chimneys as follows:
   1. Guy wires.
   2. Rigid pipe braces.

3. Rigid angle-iron braces.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Lap joints in direction of flow.

3.4 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

3.5 PROTECTION

A. Temporary Closure: Provide at ends of breechings and chimneys that are not completed or connected to equipment.

END OF SECTION

CONDENSING BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, factory-fabricated and assembled, gas-fired, condensing boilers, trim, and accessories for generating hot water.

1.2 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
   1. Wiring Diagrams: Power, signal, and control wiring. A laminated copy of the wiring diagram shall be affixed to the boiler near the electrical panel.

C. Source quality-control test reports.

D. Field quality-control test reports.
   1. Startup Reports: Submit reports documenting the activities required to be performed in PART 3. These reports are to be submitted two weeks after the startup is completed.

E. Operation and Maintenance Data: Provide two operations and maintenance manuals, including boiler and burner drawings, schematics including fuel trains, general instructions for maintenance inspections, complete spare parts list and troubleshooting procedures.

F. Other Informational Submittals:
   1. Provide efficiency curves, showing boiler thermal efficiency vs. return water temperature at 25%, 50%, 75% and 100% input.

G. Training Reports: Submit reports on training documenting dates and attendance.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. LEED/ASHRAE/IESNA 90.1-2004 Compliance: Provide certification that boilers shall have minimum efficiency according to Table 6.8.1F, "Gas and Oil Fired Boilers - Minimum Efficiency Requirements".

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 431, "Energy Efficiency Program for Certain Commercial and Industrial Equipment: Test Procedures and Efficiency Standards for Commercial Packaged Boilers."

E. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by Underwriters Laboratories

1.4 DELIVERY, STORAGE AND HANDLING

A. Follow manufacturer’s instructions for unloading, rigging and storage of equipment.

B. Maintain manufacturer’s recommended temperature and humidity limits during storage and installation. Protect equipment from dirt, dust and other jobsite contaminants and conditions detrimental to the equipment.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.6 WARRANTY

A. Warranty Period for Fire-Tube Condensing Boilers:
   1. Written manufacturer’s warranty on materials and labor for 12 months starting from preliminary acceptance, or 18 months from startup, whichever is longer.
   2. Leakage and Materials: 10 years from date of preliminary acceptance.
   3. Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated for five years from date of preliminary acceptance.

CONDENSING BOILERS

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The specification has been written with the intent to include the following boiler models.
   1. AERCO International (Model KC-1000)
   2. Lochinvar (Knight XL)
   3. Fulton (Model VTG)

2.2 PERFORMANCE REQUIREMENTS

A. General: Provide documentation showing that the boiler will meet or exceed the performance criteria as described in the following subparagraphs.

B. The boiler shall operate at a minimum 90% efficiency under the following conditions:
   1. 25% to 50% firing rate with 122°F return water temperature.
   2. 75% firing rate with 100°F return water temperature.
   3. 100% firing rate with 93°F return water temperature.

C. Verification: Submit manufacturer's published efficiency curves for submitted boiler. Efficiency curves shall be generated using the test criteria established in GAMA/Hydronics Institute publication BTS-2000, "Method to Determine Efficiency of Commercial Space Heating Boilers."

2.3 MANUFACTURED UNITS

A. Description: Factory-fabricated, assembled, and tested, condensing boiler with heat exchanger sealed pressure-tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.

B. Heat Exchanger: The heat exchanger section will be either all stainless steel or carbon steel in the non-condensing section and stainless steel in the condensing section.

C. Pressure Vessel: The section of the boiler will be constructed of stainless steel or carbon steel with welded heads and tube connections.

D. Burner: Modulating natural gas, forced draft. Provide a minimum turndown ratio of 5 to 1, inlet burner silencer and tight shutoff inlet air louvers.

E. The burner air damper and fuel gas valve on each boiler-burner unit shall be operated by a motor or motors controlling both fuel and air supply. The fuel air drive shall be provided with a position indicating switch which shall be inter-locked with the flame safeguard system, to assure starting in the low fire position. Each burner shall have automatic modulation from a separate operating control. Provide in each boiler control panel a manual/automatic switch and potentiometer, for manual control of the firing rate from 20% to 100% of rated capacity over the full firing range.

F. Burner shall be equipped with a complete system of safety devices, including the electronic flame safeguard control with pre and post purge. Pre-purge shall be a full open purge of sufficient time to provide four air change ignition purges of the combustion chamber or a full 30 second duration pre-purge. All controls shall be approved by UL.

G. Provide one (1) self closing valve with a fusible switch at ceiling above the burners to shut off gas supply to burner upon sensing ambient temperature of 210 degrees.

H. Provide terminal strip for emergency fuel shut off switch. If switch is not provided by the Division 23 Section "Building Automation System (BAS)" it will be provided by this specification. Switch shall be complete with red and white cover plate clearly marked, "Emergency Shut Off Switch

I. Interlock control requirements
   1. The boiler manufacturer will furnish all required control interlocks between the boiler-burner and related equipment as herein specified and as follows:
      a. Contacts as required for all remote alarms.
      b. Relays for remote boiler room combustion air dampers (if applicable).
      c. Contacts for remote enable/disable of boiler-burner
      d. Relays for remote gas booster enable/disable.

J. Blower: Fan to operate during each burner firing sequence and during prepurge and post purge the combustion chamber.

1. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
    a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

K. Gas Train: ASME CSD-1, IRI.

L. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

M. Casing:
1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Insulation: Minimum 2-inch thick, mineral-fiber insulation surrounding the heat exchanger.
4. Combustion-Air Connections: Inlet and vent duct collars.
5. Mounting base to secure boiler to concrete base.

2.4 TRIM

A. Aqua stat Controllers: Operating, firing rate, and high limit.

B. Safety Relief Valve: ASME rated.

C. Pressure and Temperature Gage: Minimum 3-1/2-inch diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.

D. Boiler Air Vent: Automatic.

E. Drain Valve: Minimum NPS 3/4 hose-end gate valve.

F. Flue gas trap and Condensate neutralization basin.

2.5 CONTROLS

A. For each boiler, operating controls shall include the following devices and features:
1. Control transformer.
2. Set-Point Adjust: Set points shall be adjustable.
3. All wiring to be number coded at every termination. Numbering system to be professionally printed on heat-shrink tubing at the point of connection. Wiring diagrams shall clearly indicate wiring numbers and termination points. Provide separate contacts for a remote alarm.
4. Factory installed Hand-Off-Automatic switch for interface to BAS. When operating in the Hand position the burner modulation will be via internal boiler controls.
5. Power disconnect switch.
6. Provide combustion air damper relay when combustion damper is used in design
7. A ladder diagram of the boiler/burner controls laminated permanently on the inside panel door.
8. All terminals shall be uniquely identified with an alpha numeric sequence.
9. All wires shall be uniquely identified with an alpha numeric sequence.
10. A clear distinction shall be made of wiring to non-boiler vendor devices.

B. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
1. High Cutoff: Automatic reset stops burner if operating conditions rise above maximum boiler design temperature.
2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual -reset type (UL, CSD-1).
3. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
5. Provide auxiliary contacts for monitoring from building management system, if applicable.

C. Building Management System Interface: Factory install hardware and software to enable building management system to monitor, control, and display boiler status and alarms.
1. Hardwired Points: as a minimum, the building management system shall be provided with a terminal strip including the following points and any additional points required. (See Division 23 Section "Building Automation System (BAS) - Sequence of Operation" for complete control requirements):

a. Monitoring: On/off status, common trouble alarm, low water level alarm, firing rate when the BAS commands hot water sepoint.
b. Control: On/off operation, control power to open combustion air damper (if damper is utilized), hot water supply temperature set-point adjustment or firing rate.

D. For projects that do not provide a building management system or require the BAS to control the boilers, provide a boiler system control panel that will control the staging, lead boiler alternation and firing rate to maintain the common supply water temperature.
1. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
2. The panel will use its own out side air temperature to reset boiler water temperature. The hot water common supply setpoint reset schedule will be adjustable at the boiler system control panel.

2.6 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

2.7 VENTING KITS

A. Kit: Complete system, ASTM A 959, Type 29-4C stainless steel or positive-pressure stainless steel 316L double-wall stack listed under UL certification number 1738, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.

B. Combustion-Air Intake: Complete system, duct, vent terminal with screen, inlet air coupling, and sealant.

2.8 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Basic HVAC Materials and Methods," and concrete materials and installation requirements are specified in Division 03.

B. Vibration Isolation: Elastomeric isolation pads with a minimum static deflection of 0.25 inch. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration Controls for HVAC."

C. Install gas-fired boilers according to NFPA 54.

D. Assemble and install boiler trim.

E. Install electrical devices furnished with boiler but not specified to be factory mounted.

F. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Division 23 Section "Basic HVAC Materials and Methods."

E. Connect gas piping with isolation valve and dirt leg to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required. Route gas train vents line size to the outdoors. Maintain minimum 15’ from all building openings. See drawings for additional requirements.

F. Hot water inlet and outlet connections: At a minimum connect inlet to the boiler with isolation valve, y-strainer w/ hose connection, P and T tap, manual air vent, controller-bulb well, thermometer, pressure gauge, drain connection valve and union or flange. At a minimum connect outlet to the boiler with isolation valve, control valve, calibrated balance valve, P and T tap, manual air vent, thermometer, controller-bulb well, pressure gauge, drain connection valve and union or flange. See drawings for additional requirements. Utilize a single pressure gauge with isolation valves across the boiler inlet and outlet in lieu of individual gauges to eliminate gauge error.

G. Install piping from safety relief valves to nearest floor drain.

H. Boiler Venting: Install flue venting kit and combustion-air intake.

I. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

J. Connect wiring according to Division 26 Section "Conductors and Cables for Electrical Systems."

K. Connect condensate drain lines from the boiler and flue to the neutralizing basin and flue gas trap and routed to the nearest floor drain.

L. The condensate drain lines from the boiler and flue to the neutralizing basin will be piped with polypropylene or schedule 80 PVC designed for acidic applications. The pipe downstream of the neutralizing basin can be any material allowed by Division 22 for drains.

3.4 CONTRACTOR STARTUP AND REPORTING

A. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Perform installation and startup checks according to manufacturer's written instructions.
   2. Leak Test: With system filled and operating at pressure and temperature, repair leaks and retest until no leaks exist.
   3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
      a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
      b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Performance Tests:
   1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
   2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
   3. Perform field performance tests to determine capacity and efficiency of boilers.
      a. Test for full capacity.
      b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
   4. Repeat tests until results comply with requirements indicated.
   5. Provide analysis equipment required to determine performance.
   6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.

7. Notify Architect in advance of test dates.
8. Document test results in a report and submit to Architect. Submittal shall be within 4 weeks of each boilers startup.

3.5 DEMONSTRATION AND COMMISSIONING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Division 01 Section "Demonstration and Training."
   1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining the boilers. The training will occur after the startup report has been provided to the owner and the trainer will provide two (2) Installation and Operations manuals for the use of the owner’s personnel during training.
   2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational trouble shooting. If the IOM does not include a written trouble shooting guide one will be provided.
   3. Schedule training with Owner, through Architect, with at least seven days' advance notice.
   4. Training will occur in two (2) separate two (2) hour sessions, neither on the same day nor on a day that the boilers are started up.

B. Demonstrate proper operation of equipment to commissioning agent or designated owners personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements in Division 01 and 23.

C. Video record the training sessions. The manufacturer may submit a standard training video training CD for review as an alternate to video taping of the training session. The standard video must be reviewed and accepted by the owner/commissioning authority for the alternate to be acceptable.

END OF SECTION

MODULAR, INDOOR, CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes constant and variable-volume, modular air-handling units with coils and condensing units for indoor installations.

1.2 SUBMITTALS

A. Product Data: For each type of modular indoor air-handling unit indicated. Include the following:
1. Certified fan-performance curves with system operating conditions indicated.
2. Certified fan-sound power ratings.
3. Certified coil-performance ratings with system operating conditions indicated.
4. Heating, cooling and emergy recovery performance with system operating conditions indicated.
5. Motor ratings, electrical characteristics, and motor and fan accessories.
6. Material gages and finishes.
7. Filters with performance characteristics (installation and removal, tool free).
8. Dampers, including housings, linkages, and operators. Dampers and operators must comply with the requirements of Div 23 Building Automation System including the submittal requirements.
9. Accessories.
10. Required access clearances.
11. Unit sequence of operation, including flow schematic, list of contacts and signals and control accessories.
12. Wiring Diagrams: Power, signal, and control wiring.
13. Unit Manufacturer shall provide certified ratings conforming to the latest edition of AMCA 210, 310, 500 and ARHI 410.

B. Field Quality-Control Test Reports: Field Quality-Control Test Reports: Submit reports documenting the activities required to be performed in PART 3. These reports are to be submitted two weeks after the startup is completed.

C. Training Reports: Submit reports on training documenting dates and attendance.

D. LEED Submittals:
1. Credit EQ5: Certification that equipment has been provided with MERV 13 filters.

1.3 QUALITY ASSURANCE

A. Source Limitations: Obtain modular indoor air-handling units through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. NFPA Compliance: Modular indoor air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

D. ARI Certification: Modular indoor air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI. Coils shall comply with ARI 410, Forced-Circulation Air-Cooling and Air-Heating Coils.

E. Air Handling Unit safety: ETL or UL 1995

F. Air Handling Unit energy use: ASHRAE 90.1

G. Fans: AMCA 210

H. Energy recovery: Energy transfer device shall be certified to AHRI Standard 1060 and bear the AHRI seal.

I. Filter media: ANSI/UL 900 listed Class I or Class II

J. Control wiring: NEC codes and ETL requirements

K. Motors: Federally mandated Energy Policy Act (EPACT).

L. Airflow Monitoring Stations: AMCA 611-95

1.4 DELIVERY, STORAGE AND HANDLING

A. Lift and support units with the manufacturer's designated lifting or supporting points.

B. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.

C. Deliver central-station air-handling units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

D. Comply with ASHRAE 62, Section 5 (mold and corrosion resistant casings, filters upstream of wetted surfaces, and drain pan design).

E. Comply with ASHRAE 62, Section 7 (practices to be followed during construction and startup). Protect equipment from rain and other sources of moisture by appropriate in-transit and on-site procedures.

F. Follow manufacturer’s recommendations for handling, unloading and storage.

G. Protect, pack and secure loose-shipped items within the air-handling units. Include detailed packing list of loose-shipped items, including illustrations and instructions for application.

H. Protect, pack and secure controls devices, motor control devices and other electronic equipment. Do not store electronic equipment in wet or damp areas even when they are sealed and secured.

I. Separately enclose and protect control panels, electronic or pneumatic devices and variable frequency drives and pack with desiccant bags. Replace the desiccant bags every 60 days. For equipment stored in an environment with a relative humidity greater than 60%, change bags every 30 days. Do not store equipment in wet or damp areas even when they are sealed and secured.

J. Seal openings to protect against damage during shipping, handling and storage.

K. Provide shrink-wrap around entire exterior of indoor equipment. The membrane shall cover the entire top, side and end panel surfaces to fully protect the AHU during shipping and storage. Cover equipment, regardless or size or shape. Tarping is not acceptable.

L. Shrink-wrap equipment including electrical components for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust and corrosion. Keep equipment clean and dry.

M. Ship units that are not shrink wrapped in an enclosed truck or shipping container.

N. Clearly mark each AHU section with its tag number, segment sequence number and direction of airflow. Securely affix safety-warning labels. Use a 3-language format for labels.

O. Storage: Store per AHU manufacturer’s written recommendations. Store AHUs indoors in a warm, clean, dry place where the units will be protected from weather, construction traffic, dirt, dust, water and moisture. If units will sit idle for more than 6 months, obtain written recommendations from the manufacturer for long-term storage. Follow these recommendations to ensure warranty coverage.

P. Rigging: Follow manufacturer’s written instructions for rigging, off-loading, and use of rigging tools such as spreader bars, forklifts, come-a-longs, and shackles.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

B. Coordinate installation of equipment supports, and roof penetrations.

C. Coordinate size and location of structural-steel support members.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: One set for each modular indoor air-handling unit.
   2. Fan Belts: One set for each modular indoor air-handling unit fan.
   3. Gaskets: One set for each sectional joint.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide air handlers by one of the following:
   1. Venmar
   2. Mammoth
   3. Governair

MODULAR, INDOOR, CENTRAL-STATION AIR-HANDLING UNITS

2.2 MANUFACTURED UNITS

A. Air Handling Unit (AHU) consists of a base rail, structural base, insulated casing, access doors, internal components and accessories.

B. Provide AHU to meet the specified levels of performance for scheduled items including airflow, static pressure, cooling capacity, heating capacity, sound, casing leakage, panel deflection and casing thermal performance, including panels and frame members.

C. Provide internal components and accessories specified and scheduled. Components and accessories shall be installed by the AHU manufacturer in an ISO-9002 certified facility.

D. Ship units in one piece. Split units only where necessary for shipping or installation.

E. Manufacture and ship unit in segments small enough to fit through project specific building openings. See drawings.

F. Manufacturer shall provide detailed, step-by-step instructions for disassembly and reassembly.

G. For AHU segments that must be broken down for rigging and installation:
   1. Segment shall be disassembled and reassembled by manufacturer's factory-trained service personnel.
   2. Manufacturer shall perform a moisture carry over test as indicated below.
   3. Manufacturer shall provide a written statement confirming that the unit is built to the manufacturer's factory standards and that the unit will carry the full warranty.

H. Units shall be stand alone controlled, with all control devices provided and wired for single-point power connection by the Manufacturer.

I. Units shall have overall dimensions as indicated and fit into the space available with adequate clearance for service as determined by the Engineer.

J. Tags and decals to aid in service or indicate caution areas shall be provided. Electrical wiring diagrams and Installation, Operation and Maintenance Instructions Manual (IOM) shall be attached to the control panel access doors within each unit.

2.3 BASE AND FLOOR

A. Unit perimeter base shall be completely welded and constructed from (6") structural tubing and shall accommodate curb or concrete pad installation. Bolted or riveted bases are not acceptable.

B. Unit base shall be internally insulated with 4", R24 spray foam. Unit base floor shall be constructed from 4-break formed steel panels, made from 14 gauge hot rolled steel (HRS). Floor panels shall be welded to each other, creating "I" beams at each floor panel junction. Floor panel junctions shall be located at 14" increments (maximum) or less, in order to provide floor rigidity and support as required for internal components. Unit floor panels shall be welded to perimeter base frame steel tubing. Unit floor shall be factory covered with top coat industrial grade membrane to ensure air- and water-tightness as well as walk-on grip.

C. Floor membrane shall be high performance, sprayed, plural-component pure polyurea elastomer, based on amine-terminated polyether resins, amine chain extenders and prepolymers. Floor membrane shall be flexible, tough, resilient monolithic membrane with good water and chemical resistance, and shall resist to temperatures up to 250°F. Floor membrane materials shall be free of solvents and VOC's, shall be suitable for use in compartments handling conditioned air and shall comply with the requirements for the Standard for Heating and Cooling Equipment, ANSI/UL 1995, third edition, dated 02/18/2005, Section 5.10 and Section 18. Unit base under liners shall be made of 24 gauge galvanized steel.

D. Base frame construction shall include 2-stage thermal break, using gasket between base floor framing and under liners underneath, and floor membrane on top. Single wall floor construction with glued and pined insulation and no subfloor is not acceptable; non-insulated floor construction is not acceptable. Entire base frame is to be painted with a phenolic coating for long term corrosion resistance. Base frame shall be attached to the unit at the factory.

E. When rigging, base frame deflection shall be less than 1/360 of the unit length. All major components shall be supported by the base without sagging or pulsating.

F. Unit floor shall be covered with 14 gauge aluminum checker plate in walk-in sections, on top of flooring membrane.

2.4 CASING

A. Unit wall and roof rigid frame shall consist of 16 ga. prepainted galvanized formed steel corner posts and 16 ga. G90 galvanized formed steel (1" x 2") intermediate frame posts, providing stable construction allowing for removal of any panel without affecting unit structural integrity. Units without framed type of construction are not acceptable. Exterior casing panels shall be attached to the gasketed (1" x 2" [25 x 51 mm]) steel frame with corrosion resistant fasteners. Air handling unit casing shall be of the "no-through-metal" design.

B. Casing shall incorporate insulating thermal breaks as required so that, when fully assembled, there is no path of continuous unbroken metal to metal conduction from inner to outer surfaces.

C. Provide necessary support to limit casing deflection to L/200 of the narrowest panel dimension.

D. Internal partition on dual air tunnel units shall be insulated and constructed in the same manner and thickness as the unit cabinet outer liners.

E. All panel seams shall be caulked and sealed for an air-tight unit. Leakage rates shall be less than 1% at design static pressure or 9" w.c. whichever is greater.

F. Indoor units shall be provided with factory painted finish. All galvanized steel surfaces requiring paint shall be made of satincoat-finished galvanized steel of the specified gauge(s). All galvanized steel surfaces without any paint shall be made of galvanized steel of the specified gauge(s).

G. Units shall entirely be made of double wall construction. Single wall construction with coated insulation is not acceptable. Exposed insulation edges in the airstream are not acceptable. Unit panels shall be made of 18 ga. galvanized steel outer liners and 24 ga. galvanized steel inner liners.

H. Roof and wall panels shall be double wall construction using 3” [51 mm] thick, 2.5 lb/cu. ft. urethane insulation (R18).Insulation shall meet the erosion requirements of UL 181 facing the airstream and fire hazard classification of 25/50 (per ASTM-84 and UL 723 and CAN/ULC S102-M88). All insulation edges shall be encapsulated within the panels.

2.5 PRIMARY DRAIN PANS

A. Comply with the stated intent of ASHRAE Standard 62.

B. Provide a stainless steel drain pan under each cooling coil and humidifier.

C. Provide drain connection made of same material as liner at one or both ends of the pan. Weld drain connection to the drain pan. Threaded drain pan joints are acceptable if joints are easily accessible for inspection and service.

D. Insulate plumbing associated with drain pan drains and connections.

E. Provide drain pan under the complete width and length of cooling coil and humidifier sections.

F. Drain pan shall allow visual inspection and physical cleaning on 100% of the pan surface without removal of the coil or humidifier.

G. Extend drain pan downstream of coil a minimum of 10”.

H. Provide a minimum of 1” clearance between the drain pan and any coil casing, coil support or any other obstruction.

I. Provide drain pan that allows the design rate of condensate drainage regardless of fan status.

J. Provide drain pan sloped in at least two planes by at least 1/8” per foot toward a single drain location. Locate drain connection at the lowest point of the pan. The pan shall have no horizontal surfaces.

2.6 ACCESS DOORS

A. Full size access door(s) allowing for periodic maintenance and inspections shall be provided for all serviceable component. Removable panels are not acceptable.

B. Doors shall be solid double wall insulated construction. Insulation shall be the same as unit panels. Both the inner and outer liners shall be made of the same material as unit cabinet outer liner construction.

C. The door hinge assembly shall be die cast zinc with stainless steel pivot mechanism, completely adjustable. Hinges shall allow doors to open at 180° with no shear effect on the hinge side of the perimeter

gasket. The doorframe shall be extruded aluminum with a built-in thermal break barrier and full perimeter gasket. The door gasketting shall employ a double seal comprising of an adhesive neoprene compressible foam gasket on the outer door panel and an "automotive style" neoprene bulb gasket fixed onto the inner door frame for out-swing doors, "rippled" foam for in-swing doors.

D. There shall be a minimum of two heavy duty cast; UV rated; nylon handles per door. Door handles shall be operable from both inside and outside of the unit. On all access doors where moving parts could cause injury, an ETL, UL 1995, and OSHA approved tool operated safety latch shall be provided.

E. Doors shall open against pressure.

F. Access doors in all sections shall be provided with a 8" x 8" double thermal pane window consisting of laminated safety glass on the exterior and tempered glass on the interior.

G. Access doors in all sections shall be equipped with hold-open device.

H. Access doors in all sections shall be equipped with handle inter-linkage system to be able to open each door by operating only one handle.

2.7 ENTHALPY WHEEL

A. Energy transfer ratings shall be AHRI Certified™ to Standard 1060 and bear the AHRI certification seal for AHRI Air-to-Air Energy Recovery Ventilation Equipment Program based on AHRI 1060. Ratings “in accordance with AHRI 1060” without certification are not acceptable. Heat exchanger shall be tested in accordance with ASHRAE 84-91.

B. An access section shall be provided both upstream and downstream of the wheel to allow for servicing. Wheel media shall be made of 2 mil minimum corrugated aluminum. All surfaces shall be permanently bonded with a non-migrating desiccant specifically developed for water vapor transfer. Etched or oxidized surfaces are not acceptable.

C. Wheel shall transfer energy between airstreams in a counter flow configuration. Wheel cleaning shall be with low pressure air or vacuum cleaner. Dry particles up to 1,200 microns shall freely pass through the wide angle media minimizing air pressure drop.

D. Rotor casing shall be provided with a structural framework that limits rotor deflection due to air pressure differential to less than 1/32”. Wheel shall be equipped with labyrinth beam seals, brush partition seals and contact perimeter seals for wheel diameters from 54” to 120” and with brush seals for diameters less than 54”. Wheel shall be segmented to allow removal in pieces for diameters from 54” to 120”.

2.8 FANS

A. Provide a fanwall/ fan array system for unit fans.

B. The FANWALL® array shall consist of multiple, direct driven, arrangement 4 plenum fans spaced in the airway tunnel cross section to provide a uniform airflow and velocity profile across the entire airway tunnel cross section and components contained therein. The FANWALL array shall be constructed per AMCA requirements for the duty specified, (Class I, II, or III). All fans shall be selected to deliver design airflow at the specified operating TSP at the specified motor speed and as scheduled. The FANWALL array shall be selected to operate at a system Total Static Pressure that does not exceed 90% of the specified fan’s peak static pressure producing capability at the specified fan speed.

C. Fan array shall consist of multiple fan and motor “cubes”, spaced in the airway tunnel cross section to provide a uniform airflow and velocity profile across the entire airway tunnel cross section and components contained therein. Each fan/motor assembly shall be removable through a 30” wide open area. Access door located on the discharge/inlet side of the FANWALL array.

D. Wire sizing shall be determined and installed in accordance with applicable NEC Standards. Each fan cube shall be individually wired to a control panel containing a single VFD, as specified elsewhere, for the total connected horsepower for all fan motors contained in the FANWALL array.

E. The FANWALL array shall be provided with a Coplanar Silencer for sound absorption. The Coplanar Silencers (sound attenuators) shall not increase the fan total static pressure, nor shall they increase the airway tunnel length of the FWT air handling unit when compared to the same FWT air handling unit without the Coplanar Silencer array. The Coplanar Silencers will reduce the bare fan discharge sound power levels as noted below and/or in the plans. Unless otherwise specified, the acoustical silencers shall reduce the bare fan discharge sound power levels by a minimum of 15 dB, re 10-12 watts with center

frequencies of 125, 250, 500, 1,000, 2,000, 4,000 and 8,000 Hz when compared to the same unit design without the silencers. Each fan in the FANWALL array shall be provided with an Inlet Airflow Straightener to reduce the bare fan inlet and discharge sound power levels as noted below and/or in the plans.

F. All motors shall be IEEE inverter duty, premium efficiency TEFC or TEAO T-frame motors selected at the specified operating voltage, rpm and efficiency as specified or scheduled elsewhere. All motors shall include isolated bearings or shaft grounding. All motors shall be provided with an AEGIS bearing protection ring to prevent Electrical Discharge Machining (EDM) damage to the motor bearings. Motors shall be equipped with current sensors (for each individual motor), factory wired to terminal strip(s) for field connection by others to BAS/BMS interfaces.

G. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, category BV-2.5, Grade 0.55 with peak to peak deflection equal to or less than 0.235 mil at the design operating speed for the fan/motor cartridge.

H. The discharge and inlet bare fan sound power levels for each individual octave band shall not exceed the values specified or scheduled for the FANWALL® array.

I. Each fan motor shall be individually wired to a control panel containing variable frequency drive(s) (VFD). Wire sizing shall be determined, and installed, in accordance with applicable NEC standards.

J. FANWALL array(s) shall be provided with the following options:
   1. Blank-off plates shall be provided for isolating airflow through disabled FANWALL cube(s).
   2. Each fan assembly shall be supplied with a complete flow measuring system, Huntair Flow-Cone, which indicates airflow in Cubic Feet per Minute. The flow measuring system shall consist of a flow measuring station with four static pressure taps and four total pressure tubes located at the throat of the fan inlet cone. The flow measuring station shall not obstruct the inlet of the fan and shall have no effect on fan performance (flow or static) or sound power levels. A surface mounted indicator, located on the unit exterior, shall provide a (digital) (analog) cfm readout, and/or a (4-20 ma) [0-10 volt] output control signal for use in the BAS as specified elsewhere.

K. Flow Monitoring System: As required by system design, each fan assembly shall be supplied with a complete flow measuring system, Huntair Flow-Cone, which indicates airflow in cubic feet per minute. The flow measuring system shall consist of a flow measuring station with four static pressure taps and four total pressure tubes located at the throat of the fan inlet cone. The flow measuring station shall not obstruct the inlet of the fan and shall have no effect on fan performance (flow or static) or sound power levels. A surface mounted indicator, located on the unit exterior, shall provide a digital cfm readout, and a 4–20 ma output control signal for use in the BAS as specified elsewhere.

2.9 ELECTRICAL MOTORS

A. Motors are specified in Division 23 Section “Common Motor Requirements for HVAC Equipment.”

B. Provide a complete electrical system required to run the FANWALL array system including all equipment, material, electrical enclosure and electrical components. FANWALL array designs shall be in accordance with specific system requirements. FANWALL array electrical designs shall be in accordance with the NEC, UL 508A, and Local Codes.

C. Motor Current Protection: All motors in the FANWALL array shall be provided with individual motor protection for thermal overload protection. All motor circuit protectors shall be located in main enclosure.

D. All motor circuit protectors shall be mounted and located in a remote motor circuit protector panel as needed that is separate from the main enclosure. Motor circuit protector enclosure must be located and mounted at a minimal distance from motors in the FANWALL array.

E. FANWALL TECHNOLOGY (FWT) with Variable Frequency Drive Control: As required by system design, provide a single variable frequency drive to start and run all motors in the FANWALL array. The variable frequency drive shall be sized accordingly to start and hold all motors in the FANWALL. Provide short circuit protection of motor circuits through means of using fuses with fuse blocks or circuit breakers.

F. The variable frequency drive shall be mounted in a dedicated enclosure for connection to single-point power. Variable frequency drive enclosure shall be provided with a main disconnecting means. Provide appropriate cooling of enclosure.

G. Motor circuit protectors shall be used for each motor in the FANWALL® array. Motor circuit protectors shall be housed and mounted in the VFD enclosure as required. Motor circuit protectors may be mounted in a

remote enclosure that is separate from VFD enclosure if design requires. Variable frequency drive enclosure and remote motor circuit protector enclosure must be mounted at a minimal distance from fan array motors and each other.

H. Provide three-phase power distribution wiring and control wiring as required. All three-phase power components shall have a rating listed for Short Circuit Current Rating. Provide control wiring and components required for complete operation of FANWALL system. System controls, controls components and control wiring shall include but is not limited to auto mode or manual mode, cfm control mode or BMS control mode. Controls and control wiring shall include auto start/stop, manual start/stop, life safety shutdown, smoke shutdown, system alarms and VFD alarms. All control wiring shall be included in VFD enclosure provided with system.

2.10 HEATING AND COOLING COMPONENTS

A. Provide coils with ratings certified in accordance with ARI Standard 410 for coil capacity and pressure drop. Circuit coils such that the fluid velocity is within the range of certified rating conditions at full design flow.

B. Provide cooling coils with a maximum face velocity of 500 fpm or less as required to ensure that all condensate falls or drips into the drain pan. The coil and drain pan assembly must meet this requirement whenever the humidity ratio is equal to or less than the design entering conditions and the outlet temperature is at the design leaving condition . Face velocity calculations shall be based on the finned area of the coil only.

C. Provide cooling coil segment design that does not require a drain pan in any downstream section to contain the coil condensate. Drain pan shall extend a minimum of 10” downstream of the face of the coil.

D. Direct Expansion Coils: Coils shall be tested to be leak-free with nitrogen or dry (at least 300 psig) air underwater. Standard construction connections shall be sweat-soldered and constructed of copper. Distributor shall be designed to have a removable nozzle to allow for installing an auxiliary side connection for hot gas bypass. Provide intermediate drain pans on all stacked cooling coils. The intermediate pan shall drain to the main drain pan through a copper downspout.

E. Coil tube size shall be 3/8", coil wall thickness shall be 0.016" with fins shall be made of 0.0075" thick aluminum and mechanically bonded to copper tubes.

F. Refrigerant Circuits - Entire unit, including all refrigeration circuits, shall be manufactured as one single system, at the same time and location, by the unit Manufacturer. Refrigeration section shall be designed for full and easy access for maintenance. Entire refrigerant piping circuit shall be leak-tested at 150 psig air pressure. Capacity modulation shall be provided by modulation capacity compressor and/or by hot gas bypass on lead compressor(s).

G. Refrigerant circuit components shall include: thermal expansion valve, distributor, liquid line filter drier, charging valve and high and low pressure side gauge ports. Refrigerant circuits may also include:

H. All refrigerant piping shall be of K, L or ACR copper type. The complete system shall be factory dehydrated and pressure tested at 300 psi; the system shall then be factory charged with refrigerant (except for units shipped in multiple sections where refrigeration circuit is split in multiple sections; in such case the units shall be shipped with nitrogen holding charge). Refrigerant shall be R410a

I. Suction and hot gas bypass lines shall be insulated with 3/8"thick elastomeric pipe insulation. Safety controls shall include a high and low refrigerant pressure switch on each circuit for protection against loss of charge. Each refrigerant circuit shall include DDC controlled compressor anti-cycling. Each refrigerant line present in other compartments than only the compressor compartment shall be clearly identified with the use of labels showing both the refrigerant line's duty (suction, liquid, discharge, hot gas bypass, hot gas reheat) along with the circuit number (i.e. suction 1, liquid 3, etc). This labeling shall be repeated in each compartment of the unit (else than the compressor compartment) where refrigerant lines are present, in such a way that all refrigerant lines in any other compartment can easily be identified. Unit water inlet and water outlet lines shall be clearly identified with the use of labels showing "water inlet" and "water outlet" near the point of connection to the building's water network.

2.11 INTEGRATED WATER SOURCE HEAT PUMP

A. : Each refrigerant circuit shall include externally equalized thermostatic expansion valve and reversing valve. Safety controls shall be manual reset on both low and high pressure sides.

B. Condenser shall be of coaxial tube-in-tube type, provided with copper inner tubes and steel outer tubes (shells), selected with 15°F sub-cooling, and have maximum working pressures of 400 psig on the water side and 620 psig on the refrigerant side. Condensers shall be UL and CSA approved.

C. The complete refrigerant piping shall be factory tested in both the heating and cooling modes with full water flow on factory charged units. Water piping connections to the unit shall be NPT type. On indoor units, main water connections shall be external to the unit; on outdoor units, main water connections shall be internal to the unit.

D. Provide the following :
1. Head pressure control valves, actuator modulated, controlled by DDC via pressure reading (mechanical valves not controlled via DDC are not acceptable).
2. Unit shall be suitable for geothermal applications.
3. Unit shall have a low leaving water temperature (freezestat) safety switch.
4. Water shut-off valves, actuator modulated, controlled by DDC.

E. Scroll Compressors: Compressor shall be hermetically sealed scroll type with a forced-feed lubrication system and oil charge. Compressor motor shall be suction-cooled motor windings with inherent internal line break protection and mounted on RIS vibration isolators. Compressor shall include internal pressure relief valve, gas sensor and device to limit the shut-down noise caused by scroll reversal. Each compressor shall have a crankcase heater that is independently fused and will remain energized at all times unless unit is disconnected at the main power source.

F. Lead compressor shall be capable of seamless capacity modulation from 10% to 100% of its nominal capacity, without the use of hot gas bypass. Lead compressor shall be designed to be able to operate free of oil return problems, when installed with length of interconnecting pipe up to 300 ft. and vertical elevation up to 90 ft. Oil shall return to the compressor without the use of oil separator or oil return cycle.

G. Provide compressor sound blankets.

2.12 FILTERS

A. Provide side loading filters for filter segments located upstream of the coil segment(s) with an access door on both sides through which the filters can be easily loaded. The filters must be installed and removed tool free.

B. Provide face loading filters for segments located downstream of the coil segment(s). Provide an 18” (minimum) access plenum and access doors on both sides of unit.

C. Provide Class 2 or Class 1 filter media per U.L. 900.

D. Provide filter racks constructed of galvanized steel.

E. Provide a rigid filter segment with 12” rigid media rated in accordance with ASHRAE 52, with an efficiency of 80-85% (MERV 13). Provide a pre-filter rack in the rigid filter segment with 2” 30% pleated filters.

F. Provide a flush mounted, factory installed magnahelic differential pressure gage on the drive side of the unit to measure pressure drop across each filter bank individually. Manufacturer shall provide fully functional gauges, complete with tubing.

G. • Unit shall be equipped with Differential Pressure Drop (DPD) switches on each filter bank.

2.13 DAMPERS

A. Provide dampers by one of the manufacturers listed in Division 23 Section “Building Automation System (BAS) - Operator Interfaces.” Dampers shall be sized for the actual project specific design conditions and reviewed by the temperature controls contractor. Barn door damper sizing is unacceptable. If the AHU manufacturer cannot provide one of the exact dampers specified, properly sized for the project, the unit shall be shipped without dampers and contractor shall provide and field install dampers and blank offs.

2.14 ELECTRICAL AND CONTROLS

A. All wiring and electrical connections shall be of copper wires, copper bus bars and copper fittings throughout, except internal wire of the control transformer may be aluminum, if copper termination is provided. Power supply terminals shall be identified with permanent markers. The maximum temperature of terminals shall not exceed 167°F when the equipment is tested in accordance with its rating.

B. All high voltage wiring conduit shall consist of EMT metal conduit. All low voltage and signal wiring shall consist of Belden cable.

C. When unit section splits are present, low voltage wiring shall be split using quick connectors for quick and easy field installation. Additionally, for each set of quick connector, the male branch in one unit section and the corresponding female branch in the next unit section shall be identified with the use of a color code or numbered labels. At each high voltage line split, a junction box shall be provided in one of the sections; the wiring in the section where the junction box is located and the matching wiring in the next section shall be identified with the use of a color code or numbered labels.

D. The unit shall feature a mounted permanent nameplate displaying at a minimum the Manufacturer, serial number, model number, date of manufacture and current and voltage readings. The unit must have an ETL or UL Listing and bear the appropriate mark.

E. A recessed integral electrical control compartment shall be furnished on the side of the unit. The compartment shall be constructed to NEMA 3R requirements, provided with a hinged access door and a locking device. All components, except those not mounted directly in the unit, shall be factory mounted and wired to a labeled terminal strip. All components and wiring shall be identified using printed self-adhesive labels, consistent with the numbering used in the wiring diagrams.

F. Control components shall include, but are not limited to, single-point connection power distribution block, sub and control circuit fuses or circuit breakers, control transformers, motor starters and overloads for single-speed operation. The control system shall be factory mounted in the control compartment and shall be a stand alone microprocessor-based Direct Digital Control system, with necessary sensors and interfaces to monitor and operate all functions as outlined in the equipment/control schedule, flow schematic, sequence or required for complete unit operation. A unit mounted intelligent programmable interface device shall be included for communication, display and setpoint control and a hand/off/auto switch to allow for servicing. Control panel compartment heaters and thermostats or cooling fans with grilles or registers shall be provided if control panels components cannot be protected from their minimum or maximum ambient temperature ratings. For automatic unit start-up an external dry contact must be provided by the contractor (ex: Building Management System (BMS), BACnet, time clock, etc.). The DDC controller shall be factory programmed and factory run tested prior to shipment to verify functions and logic.

G. A flow schematic with sensor and component identification and location, interlocks, sequence of operation and factory setpoints shall be included with submittals.

H. A wiring schematic and a bill of materials shall be completed in ladder/logic format, with component labeling according to line numbers, once a release for production has been received. The wiring schematic, bill of materials and flow schematic shall be submitted prior to unit shipment and included within the units control compartment.

I. Control Systems: Units shall be provided with temperature controls. The control system shall include all safety and operating controls required to meet the equipment’s ETL or UL listing and the requirements of UL 1995. Controls to include branch and sub-circuit fusing, contactors, relays and pressure controls. Panel to be constructed to NEMA 3R requirements and will have hinged access panels.

J. The unit shall be provided with a Direct Digital Control system.

K. See Control specifications and drawings for exact sequence requirements. Variation from specified

2.15 FACTORY INSTALLED ELECTRICAL ACCESSORIES

A. Provide factory mounted disconnect in a separate NEMA-1 enclosure. Manufacturer shall wire disconnect to motors.

B. Provide a separate and independent power terminal for convenience receptacles and lights, with switches.

C. Provide low temperature fluorescent lights in fan, access, coil, service, outdoor air and mixed air segments including wiring to switches and power.

D. Provide a 120v convenience receptacle on the supply fan segment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FIELD PERFORMANCE VERIFICATION

A. AHU Cooling coil moisture carry over:
   1. With the AHU operating at maximum design airflow rate ,.
   2. Modulate return and outside air dampers to maintain a humidity ratio greater than or equal to the design coil entering conditions
   3. Modulate refrigeration to maintain a coil leaving temperature equal to or less than the design leaving temperature.
   4. Operate the AHU for 4 hours under the above conditions
   5. After 4 hours shut the AHU down and inspect the surface downstream of the coil and pan for moisture. If moisture is found determine the cause, repair and retest.

B. Record test data and results in a report. Test data will include trend data at 5 minute intervals documenting the test conditions.

C. Submit a field test report with testing data recorded. Include description of corrective actions taken.

3.3 INSTALLATION

A. General Requirements: Install per industry standards, applicable building codes and manufacturer's written instructions.

B. Temporary use: Use of AHUs for temporary heating, cooling or ventilation is strictly prohibited.

C. Concrete base: Install AHUs on a minimum 4" thick reinforced concrete pad.

D. Access clearance: Install AHUs with sufficient access space around the AHU to meet manufacturer's recommended clearances for regular service access, coil pull and fan removal. As a minimum, this clearance shall equal to the width of the AHU on one side.

E. Filters: Install one complete set of filters for testing, balancing and commissioning. Install second complete set of filters at time of transfer to owner.

F. Water Source Heatpump Segment: Install AHU plumb and level, to ensure free draining and venting through the manufacturer-provided vent and drain on each coil. Follow manufacturer labels for inlet and outlet of coil headers to ensure proper direction of coil fluid flow.

3.4 FIELD INSPECTION

A. AHU Inspection
   1. Retain manufacturer's factory-trained and factory-employed service technician to perform an inspection of the AHU and the AHU installation prior to proceeding with fan assembly inspection and startup. Technician shall inspect and verify the following as a minimum:
      a. Damage of any kind
      b. Level installation of the AHU
      c. Proper reassembly and sealing of unit segments at shipping splits.
      d. Installation of shipped-loose parts, including filters, and mist eliminators.
      e. Proper electrical, ductwork and piping connections
      f. Tight seals around wiring, conduit and piping penetrations through AHU casing.
      g. Supply of electricity from the building's permanent source
      h. Integrity of condensate trap for positive or negative pressure operation
      i. Condensate traps charged with water
      j. Removal of shipping bolts and shipping restraints
      k. Sealing of pipe chase floor(s) at penetration locations.
      l. Tightness and full motion range of damper linkages (operate manually)
      m. Complete installation of control system including end devices and wiring

n. Cleanliness of AHU interior and connecting ductwork
o. Proper service and access clearances
p. Proper installation of filters
q. Filter gauge set to zero

2. Resolve any non-compliant items prior to authorizing manufacturer to proceed with the inspection of the fan assembly

B. AHU Fan Assembly Inspection and Adjustment

1. AHU Inspection (fan assembly): Engage a manufacturer's factory-trained and factory-employed service technician to perform an inspection of the AHU fan assembly prior to startup. Technician shall inspect and verify the following as a minimum:
   a. Fan isolation base and thrust restraint alignment
   b. Tight set screws on pulleys, bearings and fan
   c. Tight fan bearing bolts
   d. Tight fan and motor sheaves
   e. Tight motor base and mounting bolts
   f. Blower wheel tight and aligned to fan shaft
   g. Fan discharge alignment with discharge opening
   h. Fan bearing lubrication
   i. Free rotation of moving components (rotate manually)
2. Should any of the above need adjustment, engage manufacturer to perform the necessary adjustments to return the items to within factory specifications.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to modular indoor air-handling units with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction. Provide ½" thick insulation on condensate piping.

E. Geothermal/ Condenser Water Connections: At a minimum connect inlet to coil with isolation valve, y-strainer w/ hose connection, P and T tap, manual air vent, controller-bulb well, thermometer, pressure gauge, drain connection valve, flex connector, and union or flange. At a minimum connect outlet to coil with isolation valve, control valve, calibrated balance valve, P and T tap, manual air vent, thermometer, controller-bulb well, pressure gauge, drain connection valve, flex connector and union or flange. For multiple coils pipe similarly and provide additional calibrated balancing valves to individually balance each coil. See drawings for additional requirements. Utilize a single pressure gauge with isolation valves across the evaporator inlet and outlet in lieu of individual gauges to eliminate gauge error.

F. Refrigerant Piping: Comply with applicable requirements in Division 23 Section "Refrigerant Piping." Connect to supply and return coil tapings with shutoff valve and union or flange at each connection. Coil piping shall be per drawing details.

G. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connections.

H. Electrical: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.

I. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

J. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.6 CLEANING

A. Clean unit per manufacturer's recommendation.

MODULAR, INDOOR, CENTRAL-STATION AIR-HANDLING UNITS

3.7 CONTRACTOR STARTUP AND REPORTING

A. Engage manufacturer’s factory-trained and factory-employed service technician to startup AHUs. Startup service includes the testing, inspections and startup test reports. Technician shall perform the following steps as a minimum:
   1. Energize the unit disconnect switch
   2. Verify correct voltage, phases and cycles
   3. Energize fan motor briefly (“bump”) and verify correct direction of rotation.
   4. Re-check damper operation; verify that unit will not operate without both an inlet and an outlet damper open.
   5. Energize fan motors and verify that motor FLA is within manufacturer’s tolerance of nameplate FLA for each phase.
   6. If AHU is provided with a factory-mounted variable frequency drive (VFD), then retain the VFD manufacturer’s factory-trained and factory-employed service technician to inspect, test, adjust, program and start the VFD. Ensure that critical resonant frequencies are programmed as ‘skip frequencies’ in the VFD controller.
   7. Coordinate startup of AHU, controls and VFD with representative personnel from each supplier.
   8. Submit a startup report documenting all steps performed and summarizing findings and activities performed.

3.8 DEMONSTRATION AND COMMISSIOINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air handling units.
   1. Train Owner's maintenance personnel on procedures and schedules for startup and shutdown procedures as well as regular operation, maintenance requirements, and troubleshooting of the AHU and factory mounted controls including starters, VFD,. The training will occur after the startup report has been provided to the owner and the trainer will provide two (2) Installation and Operations manuals for the use of the owner’s personnel during training including the startup report.
   2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational trouble shooting. If the IOM does not include a written trouble shooting guide one will be provided. A list of all required maintenance will be provided.
   3. Schedule training with Owner, through Architect, with at least seven days' advance notice.
   4. Training will occur in two (2) separate two (2) hour sessions, neither on the same day the AHU is started up.

B. Demonstrate proper operation of equipment to commissioning agent or designated owners personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements in Division 01 and 23.

END OF SECTION

SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes split-system air-conditioning units consisting of separate evaporator-fan and compressor-condenser components.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. LEED Submittals:
   1. Product Data for Credit EA 4: Refrigerants documentation including printed statement that refrigerants are free of HCFCs.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.

D. Field quality-control reports.

E. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

F. Recording(s) of training session(s).

G. Warranty: Sample of special warranty.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in Chicago Electric Code, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:
   1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
   2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-latest edition, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-Up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-most current version.

1.4 COORDINATION

A. Ground-Mounted Remote Condensing Units: Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Roof-Mounted Remote Condensing Units: Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period:
      a. Compressor: Six years from date of Preliminary Acceptance or Substantial Completion.
      b. Parts: One year from date of Preliminary Acceptance or Substantial Completion.

1.6 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: One set for each air-handling unit.

SPLIT-SYSTEM AIR-CONDITIONERS

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carrier Corporation; Home Comfort and HVAC Building and Industrial Systems.
2. Mitsubishi Electric and Electronics USA, Inc.; HVAC Advanced Products Division.
3. SANYO North America Corporation; SANYO Fisher Company.

2.2 INDOOR UNITS (5 TONS OR LESS)

A. Wall-Mounted, Evaporator-Fan Components:
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
3. Fan: Direct drive, centrifugal.
4. Fan Motors:
a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Division 23.
b. Multi-tapped, multi-speed with internal thermal protection and permanent lubrication.
c. Enclosure Type: Totally enclosed, fan cooled.
d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
f. Mount unit-mounted disconnect switches on exterior or interior of unit.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-latest edition.
6. Condensate Drain Pans:
a. Fabricated with one or two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1-latest edition.
2) Pan Depth: 1 inch, minimum.
b. Single-wall, non-corrosive non-condensing with moisture tight seal.
c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
1) Minimum Connection Size: NPS 1.
7. Air Filtration Section:
a. Comply with NFPA 90A.
b. Minimum Arrestance: According to ASHRAE 52.1 and MERV according to ASHRAE 52.2.
c. Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
d. Disposable Panel Filters:
1) Thickness: 1 inch.
2) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

2.3 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:
1. Casing: Steel, finished with baked enamel, in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
a. Compressor Type: Scroll.

b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
c. Refrigerant Charge: R-407C or R-410A as scheduled.
d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid sub-cooler. Comply with ARI 210/240.

3. Fan: Aluminum-propeller type, directly connected to motor.
4. Motor: Permanently lubricated, with integral thermal-overload protection.
5. Low Ambient Kit: Permits operation down to -20 deg F.
6. Mounting Base: Polyethylene.

2.4 ACCESSORIES

A. Thermostat: Low voltage with sub-base to control compressor and evaporator fan.
1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection including auto setting.

B. Automatic-reset timer to prevent rapid cycling of compressor.

C. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

D. Drain Hose: For condensate.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install ground-mounted, compressor-condenser components on 4-inches thick, reinforced concrete base that is 4 inches larger, on each side, than unit, with cast-in anchor-bolt inserts. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-In-Place Concrete."

D. Install roof-mounted, compressor-condenser components on equipment supports specified in Division 07 Section, "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

E. Install and connect pre-charged refrigerant pipes to component's quick-connect fittings. Install pipes to allow access to unit.

3.2 PIPE CONNECTIONS

A. Pipe installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Pipe installations shall allow space for service and maintenance of system components.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
1. Leak Test: After installation, charge system and test for leaks. Repair leaks and repeat test until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Controls and Safeties: Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

SPLIT-SYSTEM AIR-CONDITIONERS

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 TRAINING AND DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain unit as specified below:
   1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining system components. The training will occur after the startup report has been provided to the Owner and the trainer will provide four Installation and Operation manuals for the use of the Owner’s personnel during training.
   2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational troubleshooting. If the IOM does not include a written troubleshooting guide, one will be provided.
   3. Schedule training with Owner, through Architect, with at least seven days advance notice.

B. Demonstrate proper operation of equipment to commissioning agent, if one, and designated Owner’s personnel. The scope of the demonstration shall include functional performance requirements under local control as well as any commissioning requirements in Division 01 and 23.

C. Video record the training session(s). The manufacturer may submit a standard training video or training CD for review as an alternate to recording of the training session. The standard video must be reviewed and accepted by the Owner and Commissioning Authority, if one, for the alternate to be acceptable.

END OF SECTION

WATER SOURCE UNITARY HEAT PUMPS

PART 1 - GENERAL

1.1 WORK INCLUDES

A. Base Bid:
   1. Mechanical Contractor
      a. Provide heat pump units specified herein.
      b. Provide controls for heat pump units specified herein.
      c. Provide ground loop piping to heat pump units specified herein..
   2. Electrical Contractor
      a. Provide electrical power to heat pump units specified herein.

1.2 SECTION INCLUDES

A. This Section includes the following types of water-source heat pumps:
   1. Horizontal and Vertical, water source Heat pumps.
   2. Water to water heat pumps.

1.3 RELATED REQUIREMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections include the following:
   1. Section 230513 - Common Motor Requirements for HVAC Equipment
   2. Section 230523 - General-Duty Valves for HVAC Piping
   3. Section 230529 - Hangers and Supports Equipment
   4. Section 230548 - Vibration Controls for HVAC Piping and Equipment
   5. Section 230553 - Identifications for Heating Piping and Equipment
   6. Section 230593 - Testing, Adjusting, and Balancing for Heating/ Ventilation
   7. Section 232113.33 - Ground-Loop Heat Exchanger
   8. Section 232123 - Hydronic Pumps

C. Should the Drawings and/or Specifications require methods of construction, installation or materials, which the Contractor cannot guarantee for the indicated period of installation for this project, it shall be the responsibility of the Contractor to so inform the Architect/Engineer in writing before submitting his bid. If no such exception is received, the Contractor shall be held responsible to provide the method of construction, installation or material, which will be guaranteed for the indicated period of time. After bids are received no allowance will be made for oversight by Bidder. "The Contractor shall liable to the Owner or Architect/Engineer for any additional cost resulting from errors, inconsistencies, or omissions in the Contract Documents unless the Contractor recognized or should have recognized such error, inconsistency, or omission, and failed to report it to the Architect/Engineer prior to bid due date, in which case the Contractor shall not be entitled to an increase in the Contract Sum or Contract Time and the Contractor shall bear all attributable costs for correction/replacement/adaptation.

D. When there is any form of errors, inconsistencies, or omissions in the Contract Documents (between Specifications and Drawings) the ventilation/Mechanical Contractor shall provide the cost in their bid for the higher/more expensive option/means/method/material/OEM requirements for this project. Failure to notify the Architect/Engineer prior to bid to clarify/define/adjust the Contract Documents prior to bid due date, in which case the Contractor shall not be entitled to an increase in the Contract Sum or Contract Time and the Contractor shall bear all attributable costs for correction replacement/adaptation.

E. Purchasing of equipment/components/device/items shown on the contract documents that may have errors, inconsistencies, omissions, or become an obsolete product from an OEM does not entitle the ventilation/Mechanical Contractor to change orders or request for proposals. The practice of purchasing equipment/components/device/items and delivering to the site and then issuing request for information for discoveries of errors, inconsistencies, omissions, or inadequacies shall not be entitlement to change orders nor request for proposals. It shall be the responsibility to provide professional practice of having prior knowledge and expertise in all equipment/components/device/items purchased for the OEMs for the installation of this project.

WATER SOURCE UNITARY HEAT PUMPS

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each model.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Wiring Diagrams: Power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and maintenance data.

E. Special warranties.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with ASHRAE 15.

C. Comply with minimum COP/efficiency levels according to ASHRAE/IESNA 90.1.

D. Comply with NFPA 70.

E. Comply with safety requirements in UL 484 for assembly of free-delivery water-source heat pumps.

F. Comply with safety requirements in UL 1995 for duct-system connections.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace refrigeration components of water-source heat pumps that fail in materials or workmanship within five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 HORIZONTAL/VERTICAL WATER-SOURCE HEAT PUMPS

A. Manufacturers:
   1. ClimateMaster, Inc.
   2. Carrier Corporation.
   3. Water Furnace

B. Description: Units shall be supplied completely factory built for an entering water temperature range from 20° to 120°F as standard. All equipment listed in this section must be rated and certified in accordance with American Refrigeration Institute / International Standards Organization (ARI / ISO) and Environmental Testing Laboratories for United States and Canada (ETL-US-C). The units shall have ARI / ISO and ETL-US-C labels. All units shall be fully quality tested by factory run testing under normal operating conditions and water flow rates as described herein. Quality control system shall automatically perform via computer: triple leak check, pressure tests, evacuate and accurately charge system, perform detailed heating and cooling mode tests, and quality cross check all operational and test conditions to pass/fail data base. Detailed report card will ship with each unit displaying all test performance data. Note: Units tested without water flow are not acceptable.

C. Horizontal Units shall have one of the following air flow arrangements: Left Inlet/Straight (Right) Discharge; Right Inlet/Straight (Left) Discharge; Left Inlet/Back Discharge; or Right Inlet/Back Discharge as shown on the plans. Units must have the ability to be field convertible from straight to back or back to straight discharge with no additional parts or unit structure modification. Horizontal units will have factory installed hanger brackets with rubber isolation grommets packaged separately.

D. Vertical Units shall have one of the following air flow arrangements: Left Return/Top Discharge, Right Return/Top Discharge, Left Return/Bottom Discharge, Right Return/Bottom Discharge as shown on the plans.

E. If units with these arrangements are not used, the contractor is responsible for any extra costs incurred by other trades. All units (horizontal and vertical) must have a minimum of three access panels for serviceability of compressor compartment. Units having only one access panel to compressor/heat exchangers/expansion device/refrigerant piping shall not be acceptable.

WATER SOURCE UNITARY HEAT PUMPS

F. Compressor section interior surfaces shall be lined with 1/2 inch thick, dual density, 1-3/4 lb/ft3 acoustic type glass fiber insulation. Air handling section interior surfaces shall be lined with 1/2 in thick, single density, 1-3/4 lb/ft3 foil backed fiber insulation for ease of cleaning. Insulation placement shall be designed in a manner that will eliminate any exposed edges to prevent the introduction of glass fibers into the air stream. Units without foil backed insulation in the air handling section will not be accepted.

G. The heat pumps shall be fabricated from heavy gauge galvanized steel. Units larger than 2 tons shall have powder coat paint finish. Both sides of the steel shall be painted for added protection.

H. Standard cabinet panel insulation must meet NFPA 90A requirements, air erosion and mold growth limits of UL-181, stringent fungal resistance test per ASTM-C1071 and ASTM G21, and shall meet zero level bacteria growth per ASTM G22. Unit insulation must meet these stringent requirements or unit will not be accepted.

I. All units to have factory installed 1” discharge air duct collars, 2” factory provided, field installed filter rails with one set of 2” filters shipped with unit and factory installed unit-mounting brackets. Vertical units to have field installed discharge air duct collar, shipped loose and 2” field installed filter rails and 1 set of filters shipped with units.

J. All units must have an insulated panel separating the fan compartment from the compressor compartment. Units with the compressor in the air stream are not acceptable. The contractor shall purchase one spare set of filters and replace factory shipped filters on completion of start-up. Filters shall be standard sizes.

K. Cabinets shall have separate holes and knockouts for entrance of line voltage and low voltage control wiring. All factory-installed wiring passing through factory knockouts and openings shall be protected from sheet metal edges at openings by plastic ferrules. Supply and return water connections shall be copper IPT fittings, and shall be securely mounted flush to the cabinet corner post allowing for connection to a flexible hose without the use of a back-up wrench. Water connections that protrude through the cabinet or require the use of a backup wrench shall not be allowed. All water connections and electrical knockouts must be in the compressor compartment corner post as to not interfere with the serviceability of unit. Contractor must ensure that units can be easily removed for servicing and coordinate locations of electrical conduit and lights with the electrical contractor.

L. All units shall be supplied with a manufactory mounted internal water pump up stream of the air-to-refrigerant coil.

M. All units shall be supplied with an internally factory mounted 3-way diverting valve downstream of the air-to-refrigerant coil for maintaining leaving source water temperature based on BAS setpoint.

N. All components shall be located inside the cabinet.

O. The unit shall be supplied with extended range insulation option for ground source systems, which adds closed cell insulation to internal water lines, and provides insulation on suction side refrigeration tubing including refrigerant to water heat exchanger.

P. Fan and Motor Assembly: Blower shall have inlet rings to allow removal of wheel and motor from one side without removing housing. Units shall have a direct-drive centrifugal fan. Fan motor shall have the following characteristics:
   1. The fan motor shall be an ECM2 variable speed ball bearing type motor.
   2. The ECM2 fan motor shall provide soft starting, maintain constant CFM over its static operating range and provide airflow adjustment on its control board. The fan motor shall be isolated from the housing by rubber grommets.
   3. The motor shall be permanently lubricated and have thermal overload protection. A special dehumidification mode shall be provided to allow lower airflows in cooling for better dehumidification. The dehumidification mode shall be selectable via a jumper on the control board or may be controlled externally from a humidistat.
   4. Airflow / Static pressure rating of the unit shall be based on a wet coil and a clean filter in place. Ratings based on a dry coil and / or no filter, or on an ESP less than 0. 50 in w.g. shall NOT be acceptable.

Q. Refrigerant Circuit: All units shall contain an HFC 410A sealed refrigerant circuit including a high efficiency two-stage compressor.

WATER SOURCE UNITARY HEAT PUMPS

1. The compressor shall be designed for heat pump operation, a thermostatic expansion valve for refrigerant metering, an enhanced corrugated aluminum lanced fin and rifled copper tube refrigerant to air heat exchanger, reversing valve, coaxial (tube in tube) refrigerant to water heat exchanger, and safety controls including a high pressure switch, low pressure switch (loss of charge), water coil low temperature sensor, and air coil low temperature sensor. Access fittings shall be factory installed on high and low pressure refrigerant lines to facilitate field service. Activation of any safety device shall prevent compressor operation via a microprocessor lockout circuit. The lockout circuit shall be reset at the thermostat or at the contractor supplied disconnect switch. Units that cannot be reset at the thermostat shall not be acceptable.
2. Hermetic compressors shall be internally sprung. The compressor shall have a dual level vibration isolation system. The compressor will be mounted on computer selected vibration isolation springs to a large heavy gauge compressor mounting tray plate, which is then isolated from the cabinet base with rubber grommets for maximized vibration attenuation. All units shall include a discharge muffler to further enhance sound attenuation. Compressor shall have thermal overload protection. Compressor shall be located in an insulated compartment away from air stream to minimize sound transmission.
3. Refrigerant to air heat exchangers shall utilize enhanced corrugated lanced aluminum fins and rifled copper tube. Refrigerant to water heat exchangers shall be of copper inner water tube and steel refrigerant outer tube design. The refrigerant to water heat exchanger shall be “electro-coated” with a low cure cathodic epoxy material a minimum of 0.4 mils thick on all surfaces. The black colored coating shall provide a minimum of 1000 hours salt spray protection per ASTM B117-97 on all external steel and copper tubing. The material shall be formulated without the inclusion of any heavy metals and shall exhibit a pencil hardness of 2H (ASTM D3363-92A), crosshatch adhesion of 4B-5B (ASTM D3359-95), and impact resistance of 160 in-lbs (184 kg-cm) direct (ASTM D2794-93).
4. Refrigerant metering shall be accomplished by thermostatic expansion valve only. Expansion valves shall be dual port balanced types with external equalizer for optimum refrigerant metering. Units shall be designed and tested for operating ranges of entering water temperatures from 20° to 120°F. Reversing valve shall be four-way solenoid activated refrigerant valve, which shall default to heating mode should the solenoid fail to function.

R. Drain Pan: The drain pan shall be constructed of 304 Stainless Steel to inhibit corrosion. Drain pan shall be fully insulated. Drain outlet shall be located at pan as to allow complete and unobstructed drainage of condensate. Drain outlet for horizontal units shall be connected from pan directly to IPT fitting. No hidden internal tubing extensions from pan outlet extending to unit casing will be accepted. The unit as standard will be supplied with solid-state electronic condensate overflow protection. Mechanical float switches will NOT be accepted. Vertical units shall be furnished with a PVC slip condensate drain connection and an internal factory installed condensate trap. If units without an internal trap are used, the contractor is responsible for any extra costs to field install these provisions, and/or the extra costs for his sub-contractor to install these provisions.

S. Electrical: A control box shall be located within the unit compressor compartment and shall contain a 75VA transformer, 24 volt activated, 2 or 3 pole compressor contactor, terminal block for thermostat wiring and solid-state controller for complete unit operation. Reversing valve and fan motor wiring shall be routed through this electronic controller. Units shall be name-plated for use with time delay fuses or HACR circuit breakers. Unit controls shall be 24 Volt and provide heating or cooling as required by the remote thermostat / sensor. Disconnect switch shall be field supplied and mounted by electrical contractor.

T. Controls: Provide BAS interface card compatible with Johnson N2 or Factory mount Johnson Controls controller in each unit and provide a Johnson N2 Bus Solid State Controls on the unit as required to communicate following points to central or remote computer location:
1. space temperature
2. leaving water temperature
3. discharge air temperature
4. command of space temperature set point
5. cooling status
6. heating status
7. low temperature sensor alarm
8. low pressure sensor alarm
9. high pressure switch alarm

10. condensate sensor alarm
11. hi/low voltage alarm
12. fan "ON/AUTO" position of space thermostat as specified above
13. unoccupied / occupied command
14. cooling command
15. heating command
16. fan "ON / AUTO" command
17. fault reset command
18. itemized fault code revealing reason for specific shutdown fault (any one of 7)

2.2 HOSE KITS

A. General: Hose kits shall be designed for minimum 400 psig working pressure, and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.

B. Hose: Length 36 inches. Minimum diameter, equal to water-source heat-pump connection size.

C. Isolation Valves: Two-piece bronze-body ball valves with stainless-steel ball and stem and galvanized-steel lever handle. Provide valve for supply and return. If balancing device is combination shutoff type with memory stop, the isolation valve may be omitted on the return.

D. Strainer: Y-type with blowdown valve in supply connection.

E. Balancing Device: Mount in return connection. Include meter ports to allow flow measurement with differential pressure gage.Manual, calibrated-orifice balancing valve.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Suspend water-source heat pumps from structure with threaded steel rods and minimum 0.25-inch static deflection rubber-in-shear vibration isolators. Vibration isolators are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

B. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
   1. Connect supply and return hydronic piping to heat pump with all unions and shutoff valves and hose kits.
   2. Connect heat-pump condensate drain pan to indirect waste connection with condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

C. Duct installation requirements are specified in other Division 23Sections. Drawings indicate general arrangement of ducts. Specific connection requirements are as follows:
   1. Connect supply and return ducts to water-source heat pumps with flexible duct connectors specified in Division 23 Section "Air Duct Accessories."

D. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

E. Install piping adjacent to machine to allow service and maintenance.

F. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. After installing water-source heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

CABINET UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cabinet unit heaters with centrifugal fans and hot-water, steam and electric-resistance heating coils.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Plans, elevations, sections, and details.
   2. Location and size of each field connection.
   3. Location and arrangement of piping valves and specialties.
   4. Location and arrangement of integral controls.
   5. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which cabinet unit heaters will be attached.
   3. Method of attaching hangers to building structure.
   4. Size and location of initial access modules for acoustical tile.
   5. Items penetrating finished ceiling, including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
   6. Perimeter moldings for exposed or partially exposed cabinets.

D. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

E. Samples for Verification: Finish colors for each type of cabinet unit heater indicated with factory-applied color finishes.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For cabinet unit heaters to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 DELIVERY, STORAGE AND HANDLING

A. Follow manufacturer’s instructions for job site storage and protection of materials during construction.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Cabinet Unit Heater Filters: Furnish one spare filter.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers:

1. Hot Water Units:
   a. Engineered Air Ltd.
   b. Vulcan Radiator.
   c. Rittling
2. Electric Units:
   a. Indeeco.
   b. Marley Electric Heating; a division of Marley Engineered Products.
   c. Rittling.

2.2 CABINET UNIT HEATERS

A. Description: A factory-assembled and -tested unit complying with ARI 440.
   1. Comply with UL 2021.

B. Coil Section Insulation: ASTM C 1071; surfaces exposed to airstream shall be aluminum-foil facing to prevent erosion of glass fibers.
   1. Thickness: 1 inch .
   2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F mean temperature.
   3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.

C. Cabinet: Steel with factory prime coating, ready for field painting.
   1. Vertical Unit, Exposed Front Panels: Minimum 0.0677-inch thick, galvanized, sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
   2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0677-inch thick, galvanized, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
   3. Recessing Flanges: Steel, finished to match cabinet.
   4. Control Access Door: Key operated.
   5. Base: Minimum 0.0528-inch thick steel, finished to match cabinet, 6 inches high with leveling bolts.
   6. Extended Piping Compartment: 8-inch wider piping end pocket.

D. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   1. Pleated: 90 percent arrestance and 7 MERV.

E. Hot-Water Coil: Seamless copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain. Provide same-end connections for supply and return.

F. Steam Coil: Copper distributing tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 75 psig.

G. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, embedded in magnesium oxide. Insulating refractory; and sealed in a high-mass steel or corrosion-resistant metallic sheath with fins a minimum of 0.16 inch apart. Provide fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware. Fin surface temperature shall not exceed 550 deg. F at any point during normal operation.

H. Fan and Motor Board: Removable.
   1. Fan: Forward curved, double width centrifugal; directly connected to motor. Provide thermoplastic or painted-steel wheels and galvanized-steel fan scrolls.
   2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

I. Control devices and operational sequences are specified in Division 23 Sections "Building Automation System (BAS)" and "Building Automation System (BAS) - Sequence of Operation."

J. Basic Unit Controls:
   1. Control voltage transformer.
   2. Timer switch.
   3. Safety-switch disconnect on cover of terminal box.
   4. Mercury contactors.
   5. Fan-delay relay.

6. Aquastat with adjustable setpoint interlocked with fan.
7. Unit-mounted thermostat with the following features.
   a. Heat-off switch.
   b. Fan on-auto switch.
   c. Manual fan speed switch.
   d. Adjustable deadband.
   e. Exposed set point.
   f. Exposed indication.
   g. Deg F indication.

K. Electrical Connection: Factory wire motors and controls for a single field connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before cabinet unit heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof.

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Suspend cabinet unit heaters from structure with elastomeric hangers. Vibration isolators are specified in Division 23 Section " Vibration Controls for HVAC."

D. Install new filters in each unit within two weeks of Substantial Completion.

E. Install separate thermostats 5’ above finished floor.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Division 23 Section "Air Duct Accessories."

E. Comply with safety requirements in UL 1995.

F. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Division 26 Section "Conductors and Cables for Electrical Systems."

3.4 CLEANING

A. After construction and painting are completed, clean all exposed surfaces and vacuum interiors.

B. Retouch marred or scratched surfaces of cabinets. If units have factory-finished cabinets, use materials furnished by the manufacturer.

3.5 CONTRACTOR STARTUP AND REPORTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Operate electric heating elements through each stage to verify proper operation and electrical connections.

3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.6 DEMONSTRATION AND COMMISSIONING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

PROPELLER UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes propeller unit heaters with hot-water and electric-resistance coils.

1.2 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each unit type and configuration.

B. Shop Drawings: Submit the following for each unit type and configuration:
   1. Plans, elevations, sections, and details.
   2. Details of anchorages and attachments to structure and to supported equipment.
   3. Wiring Diagrams: Power, signal, and control wiring.
   4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For propeller unit heaters to include in emergency, operation, and maintenance manuals.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:
   1. Hot Water Unit Heaters:
      a. Airtherm; a Mestek Company.
      b. Modine Manufacturing Co.
      c. Sterling Radiator
      d. Vulcan.
   2. Electric Unit Heaters:
      a. Marley Electric Heating Company, Berko Div.
      b. Indeeco.

2.2 UNIT HEATERS

A. Description: An assembly including casing, coil, fan, and motor in vertical and horizontal discharge configuration with adjustable discharge louvers.

B. Comply with UL 2021.

2.3 CASING

A. Cabinet: Removable panels for maintenance access to controls.

B. Cabinet Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.

C. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

2.4 COILS

A. Test and rate hot-water propeller unit-heater coils according to ASHRAE 33.

B. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 325 deg F, with manual air vent. Test for leaks to 350 psig underwater.

2.5 ELECTRIC-RESISTANCE HEATING ELEMENTS

A. Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch.

PROPELLER UNIT HEATERS

Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F at any point during normal operation.

1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

2.6 FAN

A. Propeller type, aluminum wheel directly mounted on motor shaft in the fan venturi.

2.7 FAN MOTORS

A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.8 CONTROLS

A. Control Devices: Unit-mounted thermostat.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before propeller unit-heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install propeller unit heaters level and plumb.

B. Install propeller unit heaters to comply with NFPA 90A.

C. Suspend propeller unit heaters from structure with all-thread hanger rods and spring hangers with vertical-limit stop. Hanger rods and attachments to structure are specified in Division 23 Section "Hangers and Supports for Piping and Equipment." Vibration hangers are specified in Division 23 Section "Vibration Controls for HVAC."

D. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Division 23 Section "Hydronic Piping."

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Division 26 Section "Conductors and Cables for Electrical Systems."

3.4 CONTRACTOR STARTUP AND REPORTING

A. Testing: Perform the following field quality-control testing and report results in writing:
   1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. RETAIN FIRST SUBPARAGRAPH BELOW FOR UNITS WITH ELECTRIC HEAT.
   3. Operate electric heating elements through each stage to verify proper operation and electrical connections.
   4. Test and adjust controls and safeties.

B. Remove and replace malfunctioning units and retest as specified above.

PROPELLER UNIT HEATERS

3.5 DEMONSTRATION AND COMMISSIONING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain propeller unit heaters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Electrical equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Sleeve seals.
4. Grout.
5. Common electrical installation requirements.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

1.5 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:
1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."."

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel.
1. Minimum Metal Thickness:
a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product by one of the following:
   a. Advance Products and Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.

3. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
4. Pressure Plates: Stainless steel. Include two for each sealing element.
5. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
   1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants.".

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION

MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.

1.3 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

1.4 SUBMITTALS

A. Product Data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.

B. Samples: 16-inch lengths of each type of cable indicated.

C. Qualification Data: For Installer.

D. Material Certificates: For each cable and accessory type, signed by manufacturers.

E. Source quality-control test reports.

F. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with IEEE C2 and NFPA 70.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
   2. Do not proceed with interruption of electric service without Owner's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cables:
      a. American Insulated Wire Corp.; a Leviton Company.
      b. General Cable Technologies Corporation.
      c. Kerite Co. (The); Hubbell Incorporated.

d. Okonite Company (The).
e. Pirelli Cables and Systems NA.
f. Rome Cable Corporation.
g. Southwire Company.

2. Cable Splicing and Terminating Products and Accessories:
a. Engineered Products Company.
b. G and W Electric Company.
c. MPHusky.
d. Raychem Corp.; Telephone Energy and Industrial Division; Tyco International Ltd.
e. RTE Components; Cooper Power Systems, Inc.
f. Scott Fetzer Co. (The); Adalet.
g. Thomas and Betts Corporation.
h. Thomas and Betts Corporation/Elastimold.
i. 3M; Electrical Products Division.

2.2 CABLES

A. Cable Type: MV90.

B. Comply with UL 1072, AEIC CS, 8 ICEA S-93-639, and ICEA S-97-682.

C. Conductor: Copper.

D. Conductor Stranding: Concentric lay, Class B.

E. Strand Filling: Conductor interstices are filled with impermeable compound.

F. Conductor Insulation: Crosslinked polyethylene.

G. Conductor Insulation: Ethylene-propylene rubber.
1. Voltage Rating: 5 kV.
2. Insulation Thickness: 133 percent insulation level.

H. Shielding: Copper tape, helically applied over semiconducting insulation shield.

I. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.

J. Three-Conductor Cable Assembly: Three insulated, shielded conductors cabled together with ground conductors.
1. Circuit Identification: Color-coded tape (black, red, blue) under the metallic shielding.

K. Cable Armor: Interlocked galvanized steel applied over cable.

L. Cable Jacket: Sunlight-resistant PVC.

2.3 SPLICE KITS

A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.

B. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.
1. Combination tape and cold-shrink-rubber sleeve kit with rejacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.
2. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
3. Premolded, cold-shrink-rubber, in-line splicing kit.
4. Premolded EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.

2.4 SOLID TERMINATIONS

A. Multiconductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.
1. Compound-filled, cast-metal body, metal-clad cable terminator for metal-clad cable with external plastic jacket.
2. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors.

3. Heat-shrink sheath seal kit with phase- and ground-conductor rejacketing tubes, cable-end sealing boot, and sealing plugs for unused ground-wire openings in boot.
4. Cast-epoxy-resin sheath seal kit with wraparound mold and packaged, two-part, epoxy-resin casting material.

B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.
1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector.
2. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.
3. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.
4. Class 1 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.
5. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
6. Class 3 Terminations: Kit with stress cone and compression-type connector.

C. Nonshielded-Cable Terminations: Kit with compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.

2.5 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

C. Load-Break Cable Terminators: Elbow-type units with 200-A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

D. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.
1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.

F. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

G. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.6 ARC-PROOFING MATERIALS

A. Tape for First Course on Metal Objects: 10-mil- thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

B. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch thick, compatible with cable jacket.

C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2 inch wide.

2.7 FAULT INDICATORS

A. Indicators: Automatically reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.

B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.8 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-97-682 before shipping.

B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
1. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.

C. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

D. Support cables according to Division 26 Section "Common Work Results for Electrical."

E. Install direct-buried cables on leveled and tamped bed of 3-inch- thick, clean sand. Separate cables crossing other cables or piping by a minimum of 4 inches of tamped earth. Install permanent markers at ends of cable runs, changes in direction, and buried splices.

F. Install "buried-cable" warning tape 12 inches above cables.

G. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.

H. Install cable splices at pull points and elsewhere as indicated; use standard kits.

I. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits.

J. Install separable insulated-connector components as follows:
1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
2. Portable Feed-Through Accessory: Three.
3. Standoff Insulator: Three.

K. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

L. Clean cable sheath.
1. Wrap metallic cable components with 10-mil pipe-wrapping tape.
2. Smooth surface contours with electrical insulation putty.
3. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
4. Band arc-proofing tape with 1-inch- wide bands of half-lapped, adhesive, glass-cloth tape 2 inches o.c.

M. Seal around cables passing through fire-rated elements according to Division 07 Section "Penetration Firestopping."

N. Install fault indicators on each phase where indicated.

O. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

P. Identify cables according to Division 26 Section "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Testing: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Testing: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

C. Perform the following field tests and inspections and prepare test reports:
1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.
   3. Sleeves and sleeve seals for cables.

B. Related Sections include the following:
   1. Division 26 Section "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.
   2. Division 27 Section "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Qualification Data: For testing agency.

C. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Alcan Products Corporation; Alcan Cable Division.
   2. American Insulated Wire Corp.; a Leviton Company.
   3. General Cable Corporation.
   4. Senator Wire and Cable Company.
   5. Southwire Company.

C. Copper Conductors: Comply with NEMA WC 70.

D. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN, XHHW.

2.2 CONNECTORS AND SPLICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

C. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.4 SLEEVE SEALS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
1. Advance Products and Systems, Inc.
2. Calpico, Inc.
3. Metraflex Co.
4. Pipeline Seal and Insulator, Inc.

D. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
2. Pressure Plates: Stainless steel. Include two for each sealing element.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN, single conductors in raceway.

B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

I. Class 1 Control Circuits: Type THHN-THWN, in raceway.

J. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
   1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Rectangular Sleeve Minimum Metal Thickness:
   1. For sleeve rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
   2. For sleeve rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.

E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

F. Cut sleeves to length for mounting flush with both wall surfaces.

G. Extend sleeves installed in floors 2 inches above finished floor level.

H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and cable unless sleeve seal is to be installed.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."

L. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

M. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

N. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Perform tests and inspections and prepare test reports.

C. Tests and Inspections:
   1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements.
   2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
      a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
      b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
      c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Test Reports: Prepare a written report to record the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

E. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment, plus the following special applications:
   1. Underground distribution grounding.
   2. Common ground bonding with lightning protection system.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:
   1. Test wells.
   2. Ground rods.
   3. Ground rings.
   4. Grounding arrangements and connections for separately derived systems.
   5. Grounding for sensitive electronic equipment.

C. Qualification Data: For testing agency and testing agency's field supervisor.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:
   1. Instructions for periodic testing and inspection of grounding features at test wells based on NFPA 70B.
      a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
      b. Include recommended testing intervals.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
   1. Solid Conductors: ASTM B 3.
   2. Stranded Conductors: ASTM B 8.
   3. Tinned Conductors: ASTM B 33.
   4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
   5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
   6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Bare Grounding Conductor and Conductor Protector for Wood Poles:
1. No. 4 AWG minimum, soft-drawn copper.
2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.

D. Grounding Bus: Rectangular bars of annealed copper, 1/4 by 2 inches in cross section, unless otherwise indicated; with insulators. Length as required.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet in diameter.

B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches long.
2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
1. Bury at least 24 inches below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
1. Install bus on insulated spacers 1 inch, minimum, from wall 6 inches above finished floor, unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.

E. Conductor Terminations and Connections:
1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
8. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

G. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch grounding bus.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

H. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.

1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
   2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
   3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

I. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
   1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
   2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

C. Perform the following tests and inspections and prepare test reports:
   1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
   2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
      a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
      b. Perform tests by fall-of-potential method according to IEEE 81.
   3. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

D. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
3. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
4. Substations and Pad-Mounted Equipment: 5 ohms.

E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

B. Related Sections include the following:
   1. Division 26 Section "Vibration and Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Steel slotted support systems.
   2. Nonmetallic slotted support systems.

B. Shop Drawings:
   1. Trapeze hangers. Include Product Data for components.
   2. Steel slotted channel systems. Include Product Data for components.
   3. Nonmetallic slotted channel systems. Include Product Data for components.
   4. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Comply with NFPA 70.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allied Tube and Conduit.
      b. Cooper B-Line, Inc.; a division of Cooper Industries.
      c. ERICO International Corporation.
      d. GS Metals Corp.
      e. Thomas and Betts Corporation.
      f. Unistrut; Tyco International, Ltd.
      g. Wesanco, Inc.
   3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
   4. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
   5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
   6. Channel Dimensions: Selected for applicable load criteria.

B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- diameter holes at a maximum of 8 inches o.c., in at least 1 surface.
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allied Tube and Conduit.
      b. Cooper B-Line, Inc.; a division of Cooper Industries.
      c. Fabco Plastics Wholesale Limited.
      d. Seasafe, Inc.
   3. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
   4. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
   5. Rated Strength: Selected to suit applicable load criteria.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
   1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
      a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Hilti Inc.
         2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
         3) MKT Fastening, LLC.

4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
   a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Cooper B-Line, Inc.; a division of Cooper Industries.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti Inc.
      4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted [or other]support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
   1. Secure raceways and cables to these supports with two-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
   1. To Wood: Fasten with lag screws or through bolts.
   2. To New Concrete: Bolt to concrete inserts.

3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.
1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related Sections include the following:
   1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. FMC: Flexible metal conduit.

C. IMC: Intermediate metal conduit.

D. LFMC: Liquidtight flexible metal conduit.

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
   1. Custom enclosures and cabinets.
   2. For handholes and boxes for underground wiring, including the following:
      a. Duct entry provisions, including locations and duct sizes.
      b. Frame and cover design.
      c. Grounding details.
      d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
      e. Joint details.

C. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Structural members in the paths of conduit groups with common supports.
   2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AFC Cable Systems, Inc.
   2. Alflex Inc.
   3. Allied Tube and Conduit; a Tyco International Ltd. Co.
   4. Anamet Electrical, Inc.; Anaconda Metal Hose.
   5. Electri-Flex Co.
   6. Manhattan/CDT/Cole-Flex.
   7. Maverick Tube Corporation.

8. O-Z Gedney; a unit of General Signal.
9. Wheatland Tube Company.

C. Rigid Steel Conduit: ANSI C80.1.

D. IMC: ANSI C80.6.

E. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

F. EMT: ANSI C80.3.

G. FMC: Zinc-coated steel..

H. LFMC: Flexible steel conduit with PVC jacket.

I. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
2. Fittings for EMT: Compression type only.
3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.

J. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 METAL WIREWAYS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

C. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1 or as required.

D. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

E. Wireway Covers: Hinged type.

F. Finish: Manufacturer's standard enamel finish.

2.3 NONMETALLIC WIREWAYS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hoffman.
2. Lamson and Sessions; Carlon Electrical Products.

C. Description: Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections are flanged, with stainless-steel screws and oil-resistant gaskets.

D. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.

E. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.4 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Thomas and Betts Corporation.
   b. Walker Systems, Inc.; Wiremold Company (The).
   c. Wiremold Company (The); Electrical Sales Division.

2.5 BOXES, ENCLOSURES, AND CABINETS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
   2. EGS/Appleton Electric.
   3. Erickson Electrical Equipment Company.
   4. Hoffman.
   5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
   6. O-Z/Gedney; a unit of General Signal.
   7. RACO; a Hubbell Company.
   8. Robroy Industries, Inc.; Enclosure Division.
   9. Scott Fetzer Co.; Adalet Division.
   10. Spring City Electrical Manufacturing Company.
   11. Thomas and Betts Corporation.
   12. Walker Systems, Inc.; Wiremold Company (The).
   13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.

C. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

D. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

F. Metal Floor Boxes: Cast or sheet metal, rectangular.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.

I. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

J. Cabinets:
   1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
   2. Hinged door in front cover with flush latch and concealed hinge.
   3. Key latch to match panelboards.
   4. Metal barriers to separate wiring of different systems and voltage.
   5. Accessory feet where required for freestanding equipment.

2.6 SLEEVES FOR RACEWAYS

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.7 SLEEVE SEALS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
1. Advance Products and Systems, Inc.
2. Calpico, Inc.
3. Metraflex Co.
4. Pipeline Seal and Insulator, Inc.

D. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
2. Pressure Plates: Stainless steel. Include two for each sealing element.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.8 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. Tests of materials shall be performed by a independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
1. Exposed Conduit: Rigid steel conduit.
2. Concealed Conduit, Aboveground: Rigid steel conduit.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Comply with the following indoor applications, unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
a. Loading dock.
b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
c. Mechanical rooms.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: Rigid steel conduit.
7. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway.
8. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Riser-type, optical fiber/communications cable raceway.
9. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: General-use, optical fiber/communications cable raceway.
10. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.
   1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
   2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits in contact with concrete.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. Raceways Embedded in Slabs:
   1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
   2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.

I. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

L. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic, rigid and flexible, as follows:
   1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
   2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
   3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
   1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
   2. Where otherwise required by NFPA 70.

N. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet.
   1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
      a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F,temperature change.

b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F temperature change.
d. Attics: 135 deg F temperature change.

2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change.
3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

O. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semirecessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC in damp or wet locations not subject to severe physical damage.

P. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

Q. Set metal floor boxes level and flush with finished floor surface.

R. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Rectangular Sleeve Minimum Metal Thickness:
1. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.

E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

F. Cut sleeves to length for mounting flush with both surfaces of walls.

G. Extend sleeves installed in floors 2 inches above finished floor level.

H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway unless sleeve seal is to be installed.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Penetration Firestopping."

L. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.

M. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

N. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.4 SLEEVE-SEAL INSTALLATION

A. Install to seal underground, exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.5 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.6 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Conduit, ducts, and duct accessories for concrete-encased duct banks.

1.3 DEFINITION

A. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Product Data: For the following:
   1. Duct-bank materials, including separators and miscellaneous components.
   2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
   3. Warning tape.
   4. Warning planks.

B. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
   1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
   2. Drawings shall be signed and sealed by a qualified professional engineer.

C. Qualification Data: For professional engineer and testing agency.

D. Source quality-control test reports.

E. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

B. Comply with ANSI C2.

C. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Owner no fewer than seven days in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without Owner's written permission.

1.7 COORDINATION

A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into buildings and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions, and as approved by Architect.

1.8 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.1 CONDUIT

A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation and Backfill: Comply with Division 31 Section "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32 Sections "Turf and Grasses" and "Plants."

D. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 01 Section "Cutting and Patching."

3.2 DUCT INSTALLATION

A. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

B. Concrete-Encased Ducts: Support ducts on duct separators.

1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
2. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
    a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
    b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing rod dowels extending 18 inches into concrete on both sides of joint near corners of envelope.
3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
6. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and signal ducts.
7. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.
8. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches of the centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.3 GROUNDING

A. Ground underground ducts according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:
   1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts.
   2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.5 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Isolation of vibration induced by Mechanical and Electrical Systems from spaces for which Noise Criteria have been established in Division 1.

1.2 SUMMARY

A. Install electrical systems in a manner that minimizes transmission of objectionable vibration into the building structure. Provide electrical systems that conform to the requirements of Section 018601 – General Acoustic Requirements. Required isolation includes, but is not limited to resilient mounting of transformers, dimmer racks, motor starters, remote light fixture ballast cabinets, variable frequency motor controllers, and related conduit.

B. Provide flexible electrical conduit and connections for mechanical equipment isolated under the requirements of Sections 220548 – Noise and Vibration Control for Plumbing Systems and 230548 – Noise and Vibration Control for HVAC Systems.

1.3 RELATED WORK

A. Perform vibration isolation work in this Contract, including work described in other Divisions, to meet the product and execution requirements of this Section. Related work includes:

1. Division 22 – Plumbing
2. Division 23 – Heating, Ventilating and Air Conditioning
3. Division 26 – Electrical
4. Section 018601 – General Acoustic Requirements
5. Section 220548 – Noise and Vibration Control for Plumbing Systems
6. Section 230548 – Noise and Vibration Control for HVAC Systems

1.4 QUALITY ASSURANCE

A. Provide all vibration isolators and equipment bases for Division 26 work from the product line of a single manufacturer, unless otherwise accepted by the Acoustics Consultant.

B. Select isolators to provide uniform deflections within acceptable tolerances when supporting the equipment approved for this project. Coordinate as required with the equipment manufacturers to accomplish this.

C. Provide engineering, isolator selection, site supervision, and inspection by manufacturer's personnel who shall perform these services directly. Alert the Engineer and Acoustics Consultant of isolator selections that may result in resonances with the equipment and structural systems they are intended to isolate. Replace isolators that upon installation are found to resonate with the supported equipment.

D. Provide complete isolation systems that include all elements recommended by the manufacturer for compliance with project requirements and applicable codes, ordinances, and regulations. Include all incidental products and materials required for a complete installation even if not explicitly described in the Construction Documents.

E. Install vibration isolation systems using skilled workers trained and licensed, as applicable, by the manufacturer for installations of the types used on this project. Upon completion of the Work, provide final inspection by the manufacturer's representative and submit to the Architect and Engineer a written report authored by the manufacturer's representative certifying the correctness of installation and compliance with the approved submittal data. Include tabulation of of the static deflection expected under design and operating loads in comparison with the actual static deflection measured in the completed installations.

F. Seismic Restraint Requirements:

1. Design vibration isolation mounts to meet the current design requirements and codes defined by the Structural Engineer. Use appropriate equipment weights and force factors for the equipment used in this project.
2. Provide certification by a licensed professional engineer experienced in the design of restraints for resiliently mounted equipment, and in the employ of the manufacturer, stating that the requirements of all applicable codes, ordinances and regulations regarding seismic restraint of resiliently mounted

equipment have been met by the design. Provide shop drawings, calculations, and analysis stamped by the manufacturer's engineer and demonstrating this compliance.

G. Wind Bracing Requirements:

1. Design vibration isolation mounts to meet the design wind loads defined by the Structural Engineer and required by applicable codes. Provide calculations and certification stating compliance.

1.5 UNACCEPTABLE PRODUCTS

A. Do not used housed spring mounts on this project. Mason models C, CI, and CS; Amber-Booth moels Xl and XK; Kinetics SL and SM; and similar mounts are not acceptable.

B. Do not use captive spring mounts on this project. Provide seismic restraint by means of resilient snubbers at the perimeter of the equipment or equipment base and not by mounts that combine isolation and snubbing functions. Mason model SSLFH, Amber-Booth model SWPQ, and similar mounts are not acceptable.

C. Do not use cork as an isolation material.

1.6 STANDARDS

A. NEMA ST 20-1992; Dry Type Transformers for General Applications

B. NEMA TR 1-1993; Transformers, Regulators, and Reactors

C. American Association of State Highway Transportation Officials (AASHTO) Standard Specifications for Highway Bridges, Highway Bridge Specification, Table B: Requirements for Physical Properties of Bridge-Bearing Quality Neoprene.

1.7 ENGINEERING

A. The Construction Documents are indicative of isolation requirements. Provide complete engineering services for all components of isolation systems used in this project.

1.8 SUBMITTALS AND CHANGES

A. Submit manufacturer's data, shop drawings, and product performance certifications in accordance with Division 1.

B. Manufacturer's Data: Submit technical product data confirming that products comply with specified requirements:

1. Sound Power Ratings for all transformers.
2. Certification that variable frequency controllers are compatible with the motors they will control.
3. Illustrations and descriptions of components including, but not limited to isolators, equipment bases, thrust and seismic restraints, anchors, and accessories.
4. Operation and maintenance instructions.

C. Shop Drawings

1. Full-size details of isolation systems, including plan and section drawings indicating isolator and flexible connection locations and types, isolator and connector schedules, details for resilient penetrations, and installation details.
2. Indicate substrate construction required of other subcontractors.

D. Color code legend for elastomer capacities.

E. Samples: provide a sample of each type of isolator assembly used in the project. It is not necessary to submit samples of each pad hardness.

F. Calculations: submit manufacturer's engineer's calculations of loads, deflections, and natural frequencies for record only.

G. Certifications: provide the following:

1. Certification that elastomeric pads meet the requirements of AASHTO Highway Bridge Specification.

H. Supervision plan for manufacturer's representative in the field during installation of vibration isolation systems.

I. General Requirements for Vibration Isolation Mounts and Hangers: Provide catalog cut sheets, shop drawings, and other documents as necessary to describe the installation and its components. Include the following information:

1. Elastomeric Pads:

a. Equipment name and number
b. Operating Weight of Equipment
c. Isolator type
d. Weight supported by isolator
e. Pad bearing area
f. Pad free height
g. Pad operating height
h. Scheduled deflection
i. Proposed deflection under operating load
j. Percent deflection
k. Natural Frequency
l. Hardness and compliance with AASHTO Bridge Bearing Neoprene quality standard

PART 2- PRODUCTS

2.1 MANUFACTURERS

A. Isolator Manufacturers listed below have demonstrated an ability to comply with specifications for vibration isolation products similar to those required for this project. However, not all products made by the listed manufacturers will comply with the requirements of this specification. Subject to the requirement for a single manufacturer and the restrictions regarding unacceptable types of isolators, the products of the following manufacturers are acceptable sources for this project:

1. Mason Industries, Inc., Hauppage, New York
2. Kinetics Noise Control, Dublin, Ohio
3. Amber-Booth Company, Inc., Houston, Texas
4. E.A.R., Indianapolis, Indiana
5. RPG Diffusor Systems, Upper Marlboro, MD
6. Carlisle Hardcast, Wylie, TX
7. Acoustical Solutions, Richmond, VA

2.2 ELASTOMER REQUIREMENTS

A. Provide elastomeric elements with static deflections equal to or greater than those shown on the Construction Documents. Submittals based on rated deflections will be rejected.

B. Provide neoprene elements with a maximum hardness of 40 durometer, Shore A rating, where possible, but in no case exceeding 50 durometer. Where deflections called out in the construction documents exceed those required to achieve the specified natural frequencies, the greater deflection wil govern.

C. Meet AASHTO Highway Bridge Specifications for all neoprene products provided under this section.

2.3 CORROSION RESISTANCE

A. Treat isolators and associated hardware for resistance to corrosion to the following requirements:

1. Interior exposure:

a. Steel isolator components: PVC coating or phosphate treatment with finish coat of industrial grade enamel paint.
b. Structural steel bases and associated components: Cleaned of welding slag, primed with zinc chromate primer (steel) or metal etching primer (aluminum); industrial grade enamel finish coat.
c. Nuts, bolts, and other fasteners: zinc electroplate with etching primer and enamel paint finish coat.

2. Exterior exposure:

a. Steel components: PVC coating; or hot-dipped or electroplated zinc with neoprene or bitumastic finish coat.
b. Aluminum components: etched and painted with industrial grade enamel paint.
c. Nuts, bolts, and other fasteners: zinc electroplate with etching primer and enamel paint finish coat.

2.4 PRODUCTS

A. (Type E-1) Elastomeric Pads: Provide ¾-inch thick, 2-inch square waffle pads of 50 durometer maximum Shore A hardness. Select pads for .15-inch minimum static deflection under operating load. Acceptable products include:

1. Individual pads:

a. Mason Super W
b. Kinetics NP
c. Amber-Booth NR

B. (Type E-2) Neoprene Base-Mounted Isolators: Provide double-deflection in-shear isolators with steel bottom plates with pre-drilled bolt holes for attachment to floor or base, a threaded steel insert at the top of the isolator for attaching the equipment, and friction surfaces at both top and bottom. Coat all metal surfaces with neoprene. Design isolators for 0.25 to 0.35 inches of deflection. Acceptable products include:

1. Neoprene Base Mount Isolators:

a. Mason ND
b. Kinetics RD
c. Amber-Booth RVD

C. (Type E-3) Neoprene Wall Mount Isolators: Solid neoprene or neoprene housed in steel casing. Provide threaded insert to receive equipment mounting bolt. Select isolators of not greater than 50 durometer Shoe A hardness to provide a minimum of .10 inch static deflection in shear-mounting condition under operating load. Acceptable products include:

1. Neoprene Wall-Mount Isolators:

a. Mason BR, RBA, and RCA
b. Kinetics RQ
c. RPG Custom Neoprene Wall Mount Isolator

D. (Type E-4) Elastomeric Hangers: Provide neoprene-in-shear element mounted in a rigid steel hanger box. Mold neoprene element with a rod isolation bushing that prevents rigid contact between hanger rod and housing from vertical through an angular deflection of not less than 30 degrees in any direction. Design for .25 to .35 inch minimum static deflection at rated load. Acceptable products include:

1. Elastomeric Hangers:

a. Mason HD and WHD
b. Kinetics RH
c. Amber-Booth BRD

E. (Type E-5) Flexible Steel Conduit: Provide U.L listed flexible zinc-coated steel conduit. Provide liquid tight coating and fittings where required under Division 26. Acceptable Products include:

1. Flexible Steel Conduit:

a. American Flexible Conduit Company Type AC-90
b. International Flexible Hose Company Type RWS
c. Liquid Tight Flexible Steel Conduit:
d. Anaconda Sealtite Type UA
e. Electri-Flex Type LT Liquatight

F. (Type E-6) Flexible Conduit Connectors: Connectors for conduit over 2-inch diameter. Acceptable products include:

1. Flexible Conduit Connectors

a. Crouse Hinds type XD Expansion/Deflection Coupling
b. Anaconda Sealtite

G. (Type E-7) Fittings: Provide single- or double-setscrew type. Acceptable products include:
   1. Fittings:
      a. Appleton
      b. Kellum

PART 3 - EXECUTION

3.1 GENERAL

A. Mount transformers, dimmer racks, remote fluorescent fixture ballast cabinets, and variable frequency motor controllers on neoprene floor or wall mount isolators.

B. Use flexible connections for all electrical connections to isolated equipment provided under Divisions 22, 23 and 26.

C. Before commencing installation examine the substrate and surrounding conditions to insure that there is nothing to prevent proper and timely execution of the installation. Beginning work specified in this Section indicates acceptance of the substrate and surrounding conditions.

D. Install flexible conduit and flexible connections in conformance with manufacturer's requirements and electrical codes. Notify the Architect and Acoustics Consultant if building codes conflict with the requirements of this section.

E. Install isolation systems in strict compliance with manufacturer's recommendations and engineering, and submittal data. Make no rigid connections to structure that would compromise the performance of the isolation systems.

F. Resiliently mount or hang electrical equipment and conduit on structural components indicated on the Drawings and as specified in this section.

G. For all isolated equipment, make electrical connections as specified in this section. Make no connections to isolated equipment in a manner that would compromise the performance of the isolation systems.

H. Install seismic restraints and sway bracing in conformance with the engineered shop drawings and applicable codes, ordinances, and regulations.

I. Establish isolator locations for ease of installation, adjustment, and inspection as well as specified performance.

J. Replace isolators found to bridge to non-isolated construction or to resonate with building structure, at no additional cost to the Owner.

3.2 GENERAL REQUIREMENTS FOR MOUNTS AND HANGERS

A. Align mounts and hangers squarely above or below the equipment mounting holes to avoid introducing lateral loads and deflection.

B. Deflection requirements:
   1. Verify installed isolators have deflections equal to or greater than deflections specified on the submittals.
   2. Where multiple deflections apply to a single isolator (where a single isolator supports multiple isolated elements), the largest deflection governs.
   3. Vary the size and/or hardness of isolators as required to yield equal deflection for all isolators supporting a single piece of equipment or length of pipe or ductwork. Consult manufacturer for direction when specified isolators do not yield required deflection and correct non-compliant isolators at no cost to the Owner.

C. Support equipment and conduit independently. Do not hang equipment or conduit from other isolated equipment, ductwork, piping, or conduit.

D. Maintain 2 inches of clearance between isolated elements and walls, ceilings, and other non-isolated building components.

E. Isolate hanger rods passing through barrier ceilings with elastomeric sleeves or grommets or treat as resilient penetrations in accordance with the details and Section 079219 – Acoustical Sealants. Unless noted otherwise, locate equipment and conduit below barrier ceilings.

F. At housekeeping slabs and pedestals, position isolators with entire bearing plate on slab or pedestal. Do not cantilever base plates beyond edges of slabs and pedestals. Coordinate isolator locations with housekeeping slabs so that outboard height-saving mounts do not contact the housekeeping slabs. Notify contractor of work by others requiring remediation for proper installation of isolators.

3.3 BASE-MOUNTED EQUIPMENT ISOLATION

A. Mount transformers motor controllers, dimmer racks, and ballast cabinets on Type E-2 neoprene base-mount isolators. Maintain unobstructed clearance between the bottom of the equipment and the floor or housekeeping slab. Allow no rigid components to bridge between the isolated equipment and adjacent, non-isolated construction.

B. Smaller equipment may be wall mounted on Type E-3 wall mount isolators. Bolt through walls of cabinets or provide appropriate brackets for attachment of transformers.

3.4 SUSPENDED EQUIPMENT ISOLATION

A. Provide Type E-4 elastomeric hangers for suspended equipment. Position isolators as high as possible in the hanger rod assembly but not in direct contact with the building structure without manufacturer's written authorization. Provide 1 inch minimum clearance between isolator housing and structure above. Provide side clearance for hangers to allow full 360-degree rotation about the rod axis without encroaching into the required 1-inch clearance.

3.5 CONDUIT ISOLATION

A. Resiliently isolate rigid conduit serving vibration isolated equipment for a minimum of 15 feet or 4 supports (whichever is greater) from the equipment being isolated. Wrap conduit with 1-inch thick Armaflex or other resilient pipe insulation at wall or ceiling attachment points and size pipe clamps so that the resilient material is compressed no more than 10 percent of its thickness by the clamp.

B. Parallel conduit can be hung together on a trapeze that is isolated from the structure. Isolator deflections must be equal to or greater than the greatest deflection required for the conduit if isolated individually. Do not mix isolated and non-isolated conduit on the same trapeze.

3.6 FLEXIBLE CONNECTIONS

A. Use flexible conduit or a flexible conduit connector at each connection to vibration-isolated equipment. Provide flexible conduit of length not less than 30 times its internal diameter. Configure flexible conduit installation to provide not less than 25 percent slack under any combination of operating loads. Do not bend flexible conduit to a radius less than twice its minimum bending radius.

B. Provide liquid-tight flexible conduit where required by the specific installation.

C. Use flexible conduit or a flexible conduit connector at each instance where conduit crosses a building expansion or isolation joint.

D. Use fittings recommended by the flexible conduit manufacturer, which maintain required UL listings, and which comply with applicable codes.

E. For conduit larger than 2 inches, use pre-manufactured flexible conduit connectors instead of flexible conduit.

3.7 CONDUIT PENETRATIONS OF STRUCTURE, PARTITIONS, AND CEILINGS

A. Provide resilient penetration seals for all conduit penetrations of walls floors, and ceilings of equipment rooms, all rooms classified as Acoustically Sensitive in Section 018601 – General Acoustic Requirements and elsewhere as required by the Construction Documents. Provide the following:

1. 22 gage steel sleeve grouted rigidly in place in all wall, floor, and ceiling locations; except that sleeves may be omitted at properly sized cored or sleeved penetrations through solid concrete, solid or grouted masonry walls. And hollow partitions in which solid blocking has been placed for coring of penetrations. Size sleeves and cored holes to provide annular space of ½ to ¾ inch width around conduit. Center the conduit in the sleeve or penetration.

2. Pack the annular space with loose glass- or mineral-fiber insulation to the full depth of the wall or floor/ceiling construction. Seal completely between sleeve and conduit with Acoustical Sealant installed in accordance with Section 079219 – Acoustical Sealant.

3.8 TESTING, EVALUATION AND ACCEPTANCE PROCEDURES

A. If it is found that the construction fails the acoustic test measurements or performance requirements identified in the Contract Documents, make changes necessary to meet the requirements identified in the Contract Documents and be responsible for the costs associated with performing all additional acoustical tests to verify the acoustic performance of the construction. Costs for additional acoustical testing shall include consulting fees at per hour rates in effect at the time of testing along with related expenses including, but not limited to, travel expenses and test equipment use charges.

END OF SECTION

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Identification for raceway and metal-clad cable.
   2. Identification for conductors and communication and control cable.
   3. Underground-line warning tape.
   4. Warning labels and signs.
   5. Instruction signs.
   6. Equipment identification labels.
   7. Miscellaneous identification products.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and ANSI C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.145.

1.5 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 RACEWAY AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Color for Printed Legend:
   1. Power Circuits: Black letters on an orange field.
   2. Legend: Indicate system or service and voltage, if applicable.

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

2.2 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

C. Aluminum Wraparound Marker Labels: Cut from 0.014-inch- thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.

D. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking nylon tie fastener.

E. Write-On Tags: Polyester tag, 0.010 inch thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.3 UNDERGROUND-LINE WARNING TAPE

A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
1. Not less than 6 inches wide by 4 mils thick.
2. Compounded for permanent direct-burial service.
3. Embedded continuous metallic strip or core.
4. Printed legend shall indicate type of underground line.

2.4 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 7 by 10 inches.

D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 10 by 14 inches.

E. Warning label and sign shall include, but are not limited to, the following legends:
1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.5 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.
1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and ultraviolet-resistant seal for label.

C. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

D. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
1. Minimum Width: 3/16 inch.
2. Tensile Strength: 50 lb, minimum.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 APPLICATION

A. Raceways and Duct Banks More Than 600 V Concealed within Buildings: 4-inch- wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- high black letters on 20-inch centers. Stop stripes at legends. Apply to the following finished surfaces:
1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to raceways concealed within wall.
3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

B. Accessible Raceways and Metal-Clad Cables More Than 600 V: Identify with "DANGER-HIGH VOLTAGE" in black letters at least 2 inches high, with self-adhesive vinyl labels. Repeat legend at 10-foot maximum intervals.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A: Identify with orange self-adhesive vinyl label.

D. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands:
1. Fire Alarm System: Red.
2. Fire-Suppression Supervisory and Control System: Red and yellow.
3. Combined Fire Alarm and Security System: Red and blue.
4. Security System: Blue and yellow.
5. Mechanical and Electrical Supervisory System: Green and blue.
6. Telecommunication System: Green and yellow.
7. Control Wiring: Green and red.

E. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to source and circuit number.

F. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source and circuit number.

G. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.

H. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway.

I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply baked-enamel warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
   1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
      a. Power transfer switches.
      b. Controls with external control power connections.
   2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

J. Instruction Signs:
   1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
   2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer.

K. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
   1. Labeling Instructions:
      a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where 2 lines of text are required, use labels 2 inches high.
      b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
      c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
   2. Equipment to Be Labeled:
      a. Panelboards, electrical cabinets, and enclosures.
      b. Access doors and panels for concealed electrical items.
      c. Electrical switchgear and switchboards.
      d. Transformers.
      e. Electrical substations.
      f. Emergency system boxes and enclosures.
      g. Motor-control centers.
      h. Disconnect switches.
      i. Enclosed circuit breakers.
      j. Motor starters.
      k. Push-button stations.
      l. Power transfer equipment.
      m. Contactors.
      n. Remote-controlled switches, dimmer modules, and control devices.
      o. Battery inverter units.
      p. Battery racks.
      q. Power-generating units.
      r. Voice and data cable terminal equipment.
      s. Television/audio components, racks, and controls.
      t. Fire-alarm control panel and annunciators.
      u. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
      v. Monitoring and control equipment.
      w. Uninterruptible power supply equipment.

x. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.

3.2 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach nonadhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.

1. Colors for 208/120-V Circuits:
   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
2. Colors for 480/277-V Circuits:
   a. Phase A: Brown.
   b. Phase B: Orange.
   c. Phase C: Yellow.
3. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

H. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Painted Identification: Prepare surface and apply paint according to Division 09 painting Sections.

END OF SECTION

OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes computer-based, fault-current and overcurrent protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study.
   1. Coordination of series-rated devices is permitted where indicated on Drawings.

1.3 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

C. Qualification Data: For coordination-study specialist.

D. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals shall be in digital form.
   1. Coordination-study input data, including completed computer program input data sheets.
   2. Study and Equipment Evaluation Reports.
   3. Coordination-Study Report.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
   1. Professional engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

D. Comply with IEEE 399 for general study procedures.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Available Computer Software Developers: Subject to compliance with requirements, companies offering computer software programs that may be used in the Work include, but are not limited to, the following:

B. Computer Software Developers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   1. EDSA Micro Corporation.
   2. ESA Inc.
   3. SKM Systems Analysis, Inc.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
   1. Optional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:
1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance.
3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:
a. Circuit-breaker and fuse-current ratings and types.
b. Relays and associated power and current transformer ratings and ratios.
c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
d. Generator kilovolt amperes, size, voltage, and source impedance.
e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
f. Busway ampacity and impedance.
g. Motor horsepower and code letter designation according to NEMA MG 1.
4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
a. Special load considerations, including starting inrush currents and frequent starting and stopping.
b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
d. Generator thermal-damage curve.
e. Ratings, types, and settings of utility company's overcurrent protective devices.
f. Special overcurrent protective device settings or types stipulated by utility company.
g. Time-current-characteristic curves of devices indicated to be coordinated.
h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

3.3 FAULT-CURRENT STUDY

A. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:
1. Distribution panelboard.
2. Branch circuit panelboard.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 241 and IEEE 242.
   1. Transformers:
      a. ANSI C57.12.10.
      b. ANSI C57.12.22.
      c. ANSI C57.12.40.
      d. IEEE C57.12.00.
      e. IEEE C57.96.
   2. Medium-Voltage Circuit Breakers: IEEE C37.010.
   3. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.
   4. Low-Voltage Fuses: IEEE C37.46.

E. Study Report:
   1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.
   2. Show interrupting (5-cycle) and time-delayed currents (6 cycles and above) on medium-voltage breakers as needed to set relays and assess the sensitivity of overcurrent relays.

F. Equipment Evaluation Report:
   1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
   2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
   3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

3.4 COORDINATION STUDY

A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.
   1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
   2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.
   3. Calculate the maximum and minimum ground-fault currents.

B. Comply with IEEE 242 recommendations for fault currents and time intervals.

C. Transformer Primary Overcurrent Protective Devices:
   1. Device shall not operate in response to the following:
      a. Inrush current when first energized.
      b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
      c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
   2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

D. Motors served by voltages more than 600 V shall be protected according to IEEE 620.

E. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

F. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:
   1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
      a. Device tag.
      b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
      c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
      d. Fuse-current rating and type.
      e. Ground-fault relay-pickup and time-delay settings.
   2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices

installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

a. Device tag.
b. Voltage and current ratio for curves.
c. Three-phase and single-phase damage points for each transformer.
d. No damage, melting, and clearing curves for fuses.
e. Cable damage curves.
f. Transformer inrush points.
g. Maximum fault-current cutoff point.

G. Completed data sheets for setting of overcurrent protective devices.

END OF SECTION

LIGHTING AND LIGHTING CONTROLS COMMISSIONING

PART 1 - GENERAL

1.1 OWNER FURNISHED

A. See Section 01 91 13 – General Requirements - Commissioning

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. See Section 01 91 13 – General Requirements – Commissioning

1.3 SUMMARY

A. The purpose of the commissioning process is to provide the owner/operator of the facility with a high level of assurance that the lighting and lighting control systems have been installed in the prescribed manner, and operate within the performance guidelines set in the Contract Documents. The commissioning authority shall provide the owner with an unbiased, objective view of the system's installation, operation, and performance. This process is not intended to take away or reduce the responsibility of the design team or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems for beneficial use by the owner. The commissioning authority will be a member of the construction team, administrating and coordinating commissioning activities with the design team, construction manager, subcontractors, manufacturers and equipment suppliers.

1.4 REFERENCES

A. See Section 01 91 13 – General Requirements - Commissioning

1.5 SCOPE

A. See Section 01 91 13 – General Requirements - Commissioning

1.6 LIGHTING AND LIGHTING CONTROL SYSTEMS AND EQUIPMENT, IF INSTALLED, INCLUDED IN THE COMMISSIONING PROCESS

A. Lighting / Lighting control relays.

B. Lighting / lighting control breaker panels and controls.

C. Lighting occupancy sensors and photo-sensors

D. Lighting / Lighting control equipment / systems.

E. Light level measurements for selected occupied, worst-case scenario spaces.

PART 2 - COMMISSIONING PLAN

2.1 COMMISSIONING PLAN DOCUMENT

A. See Section 01 91 13 – General Requirements - Commissioning

2.2 COMMISSIONING TEAM

A. See Section 01 91 13 – General Requirements - Commissioning

2.3 CONTRACT DOCUMENT

A. See Section 01 91 13 – General Requirements - Commissioning

2.4 COMMISSIONING MEETINGS

A. See Section 01 91 13 – General Requirements - Commissioning

2.5 MASTER FINDINGS LIST

A. The Commissioning Authority (CxA) or installing contractor will complete Pre-Functional Testing. Commissioning Agent conducts Functional Testing with assistance of installing contractor.

B. All findings from these inspections are documented and are posted to the master findings list and website within two business days.

C. Construction Manager (CM) will regularly distribute findings list to contractors and will hold contractor accountable to: 1.) correct any items and/or 2.) provide electronic responses for each finding.

D. Responsible contractor will correct finding(s) and provide written confirmation that the finding(s) have/has been corrected. If finding was not corrected, contractor provides written explanation.

E. Commissioning findings' status may be considered during the pay application approval process. Approval may be withheld due to unresolved findings and/or findings where written responses have not been provided.

F. CM provides responses back to CxA. All responses are updated to the Master Findings List.

G. Once written responses are provided for each finding, the CxA will re-inspect. The contractor will be back-charged at a rate not to exceed the CxA contract hourly rate for any finding(s) that was/were reported to have been resolved and that are found to be unresolved upon re-inspection.

H. Status will be tracked for each finding and the Master Findings List will be updated accordingly.

I. Once all findings have been resolved and the job is completed, a Final Report will be generated and a final commissioning meeting will be held.

2.6 PRE-FUNCTIONAL TESTING / MANUFACTURER'S CHECKLISTS

A. The Commissioning Authority (CxA) or installing contractor will complete the Pre-Functional Testing forms for each piece of equipment prior to start-up.

B. The equipment manufacturers' checklists must be completed by the installing contractor and reviewed by the Commissioning Authority before start-up can commence.

2.7 START-UP

A. Start-up of Lighting / lighting controls systems may be witnessed by the commissioning authority. The appropriate contractors and/or manufacturer's representative will be required on site to perform start-up. No system will be started until the appropriate Pre-Functional Testing forms have been completed. No system will be started until the manufacturer's checklists have been completed. Start-up will be performed according to the Manufacturer's recommended procedures. The commissioning authority will review completeness of installation in conjunction with progress meetings prior to starting Lighting / Lighting control systems.

B. Construction team members involved in installation, fabrication, manufacture, control, or design of equipment are required to be present at the time of start-up. A factory-authorized technician will be on site to start equipment when required by the specifications. This will minimize delays in bringing equipment on line and expedite acceptable functional performance in accordance with the Owner's Project Requirements (OPR) and Basis of Design (BOD).

2.8 FUNCTIONAL TESTING

A. The Commissioning Authority will perform or witness installing contractor, or manufacturer's representative performing Functional Testing based on the Owner's Project Requirements (OPR) and the Basis of Design (BOD). These tests will be completed for lighting and lighting control systems.

B. Each major system will be tested. A random sample of each subsystem will be tested. This will be coordinated and witnessed by the Commissioning Authority and the owner's maintenance staff. Witnessing the Functional Testing will serve as a compliment to the O&M Training. Functional Testing will not be performed until the installer's Point Installation Verification Checklists have been submitted and reviewed by the Commissioning Authority.

2.9 BUILDING TURN-OVER / OWNER ORIENTATION / USER TRAINING

A. Owner training will be provided by the installing contractor, or manufacturer's representative, and may be witnessed by the Commissioning Authority. This training should include both classroom training and hands-on operational training. The owner may choose to videotape this training for future use. The Commissioning Authority may visit the site during the Turn-Over and Training period to assure that any on-going lighting control related problems are being addressed and corrected in a timely and efficient manner.

B. The Commissioning Authority will assist in the coordination of off-season testing, calibrating, and servicing as specified in the contract documents.

2.10 WARRANTY REVIEW

A. The commissioning authority will participate in a 10 month walk-through to observe the operation of the lighting and lighting control systems. This will include a review meeting with the owner, a discussion of warranty issues, energy usage, maintenance practices, usage changes, and chronic problems, as well as other issues affecting the owner and the operation of the lighting and/or lighting control systems.

PART 3 - EXECUTION

3.1 RESPONSIBILITIES OF LIGHTING / LIGHTING CONTROLS INSTALLER

A. The installing contractor in this division shall include in their quote the cost of participating in the commissioning process.

B. Attend commissioning specific meetings scheduled by the Commissioning Authority or Construction Manager.

C. Review design for provision of power to the all electrical equipment.
   1. Verify proper hardware specifications exist for performance as defined by the Owner's Project Requirements (OPR) and Basis of Design (BOD).
   2. Verify proper safeties and interlocks are included in the design of electrical connections for all electrical equipment.

D. Include requirements for submittal data (including partial load data), O&M data, and training in each purchase order or sub-contract.

E. Verify proper installation and performance of all electrical services provided.

F. Complete manufacturer's pre-start checklists prior to scheduling startup of lighting and/or lighting controls equipment.

G. Assure participation of major equipment manufacturers in appropriate startup, training, and testing activities.

H. Participate in the Pre-Functional and Functional Performance Tests as required to achieve design intent.

I. Monitor and respond to the Master Findings List distributed by the commissioning authority in writing within five (5) business days in order to expedite corrective actions necessary to achieve design intent. Failure to respond in writing within five business days will result in contractor non-compliance and will warrant the provision of a seventy-two (72) hour notice to comply and/or back charge to the contractor for all necessary corrective work. Items that are reported to have been corrected but that are found not to have been corrected after a maximum of two re-inspections will result in a back charge to the responsible contractor for any subsequent re-inspection that must be performed by the commissioning authority in order to verify that the corrective work has been completed.

J. Provide an electrical system technician to assist during verification testing and performance testing (Pre-Functional and Functional Testing).

K. Notify the Commissioning Authority a minimum of two weeks in advance of scheduled system start-up.

L. Participate in the off-season mode testing as required to achieve design intent.

M. Participate in O&M Training as required by project specifications.

N. Provide a complete set of as-built drawings and O & M manuals for review. The Commissioning Authority shall review the as-built drawings and O&M manuals concurrently with the design team.

O. Update drawings to as-built condition and review with the Commissioning Authority throughout the construction process.

P. In the event that any portion of the work to be completed by the electrical contractor is subcontracted, ensure compliance with the commissioning process on the part of any individual(s) performing that work. To that end, ensure that each sub-contractor is provided a copy of this specification.

END OF SECTION

ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following for monitoring and control of electrical power system:
   1. PC-based workstation(s) and software.
   2. Communication network and interface modules for RS-485, Modbus TCP/IP and IEEE 802.3 data transmission protocols.

B. Related Sections include the following:
   1. Division 26 Section "Electricity Metering" for equipment to meter electricity consumption and demand for tenant submetering.

1.3 DEFINITIONS

A. Ethernet: Local area network based on IEEE 802.3 standards.

B. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

C. HTML: Hypertext markup language.

D. I/O: Input/output.

E. KB: Short for kilobyte. When used to describe data storage, "KB" represents 1024 bytes.

F. KY Pulse: A term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay changing status in response to the rotation of the disk in the meter.

G. LAN: Local area network; sometimes plural as "LANs."

H. LCD: Liquid crystal display.

I. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less that

   50 V or remote-control, signaling and power-limited circuits.

J. Modbus TCP/IP: An open protocol for exchange of process data.

K. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

L. PC: Personal computer; sometimes plural as "PCs."

M. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

N. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.

O. RS-485: A TIA standard for multipoint communications using two twisted-pairs.

P. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

Q. THD: Total harmonic distortion.

R. UPS: Uninterruptible power supply; used both in singular and plural context.

S. WAN: Wide area network.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.
   1. Attach copies of approved Product Data submittals for products (such as switchboards and switchgear) that describe power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.

B. Shop Drawings: For power monitoring and control equipment. Include plans, elevations, sections, details, and attachments to other work.
   1. Outline Drawings: Indicate arrangement of components and clearance and access requirements.

2. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Wiring Diagrams: Power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
5. UPS sizing calculations for workstation.

C. Software and Firmware Operational Documentation:
1. Self-study guide describing the process for setting equipment's network address; setting Owner's options; procedures to ensure data access from any PC on the network, using a standard Web browser; and recommended firewall setup.
2. Software operating and upgrade manuals.
3. Software Backup: On a magnetic media or compact disc, complete with Owner- selected options.
4. Device address list and the set point of each device and operator option, as set in applications software.
5. Graphic file and printout of graphic screens and related icons, with legend.

D. Software Upgrade Kit: For Owner to use in modifying software to suit future power system revisions or power monitoring and control revisions.

E. Software licenses and upgrades required by and installed for operating and programming digital and analog devices.

F. Qualification Data: For manufacturer.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For power monitoring and control units, to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Operating and applications software documentation.
2. Software licenses.
3. Software service agreement.
4. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.
5. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD- ROM of the hard-copy submittal.

I. Other Informational Submittals:
1. System installation and setup guides, with data forms to plan and record options and setup decisions.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Manufacturer Qualifications: A firm experienced in manufacturing power monitoring and control equipment similar to that indicated for this Project and with a record of successful in-service performance.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in CBC, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.
1. Match components and interconnections for optimum performance of specified functions.

B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

1.7 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within one year from date of Substantial Completion. Upgrading software shall include the operating systems. Upgrade shall include new or revised licenses for use of software.
   1. Provide 30-day notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Addressable Relays: One for every 10 installed. Furnish at least one of each type.
   2. Data Line Surge Suppressors: One for every 10 of each type installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   1. Siemens Energy and Automation, Inc.

2.2 FUNCTIONAL DESCRIPTION

A. Instrumentation and Recording Devices: Monitor and record load profiles and chart energy consumption patterns.
   1. Calculate and Record the Following:
      a. Load factor.
      b. Peak demand periods.
      c. Consumption correlated with facility activities.
   2. Measure and Record Metering Data for the Following:
      a. Electricity.

B. Software: Calculate allocation of utility costs.
   1. Automatically Import Energy Usage Records to Allocate Energy Costs for the Following:
      a. At least five departments.
      b. At least five buildings.
   2. Verify utility bills and analyze alternate energy rates.

C. Power Quality Monitoring: Identify power system anomalies and measure, display, and record trends and alarms of the following power quality parameters:
   1. Voltage regulation and unbalance.
   2. Continuous three-phase rms voltage.
   3. Periodic max./min./avg. samples.
   4. Harmonics.
   5. Voltage excursions.

D. Emergency Load Shedding. Preserve critical loads or avoid total shutdown due to unforeseen loss of power sources according to the following logic:
   1. Determine system topology.
   2. Evaluate remaining loads and sources.
   3. Shed loads in less than 100 ms.

E. Demand Management:
   1. Load trimming.

F. System: Report equipment status and power system control.

2.3 SYSTEM REQUIREMENTS

A. Monitoring and Control System: Include multiple PC-based workstations with graphics capability and Web access, with its operating system and application software, connected to data transmission network.

B. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
   1. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Division 26 Section "Transient- Voltage Suppression for Low-Voltage Electrical Power Circuits."
   2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.

C. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.

2.4 OPERATING SYSTEM

A. Software: Configured to run on a portable laptop computer, a single PC, or a palm computer, with capability for accessing a single meter at a time. System is not connected to a LAN. Modbus TCP/IP, RS-232, and RS-485 digital communications.

B. Software: Configured to run on a single PC, with capability for accessing multiple devicessimultaneously. Modbus TCP/IP, RS-232, and RS-485 digital communications.

C. Software: Configured for a server and multiple client PCs, each with capability for accessing multiple devices simultaneously. Ethernet, Modbus TCP/IP, RS-232, and RS-485 digital communications.

D. Software: Configured for a server and multiple client PCs, each with capability for accessing multiple devices simultaneously. Software shall include interactive graphics client and shall be Web enabled. Workstations and portable computers shall not require any software except for an Internet browser to provide connectivity and full functionality. Include a firewall recommended by manufacturer. 100 Base-T Ethernet, Modbus TCP/IP RS-232, and RS-485 digital communications.

E. Operating System Software: Based on 32-bit, Microsoft Windows workstation operating system. Software shall have the following features:
   1. Multiuser and multitasking to allow independent activities and monitoring to occur simultaneously at different workstations.
   2. Graphical user interface to show pull-down menus and a menu tree format.
   3. Capability for future additions within the indicated system size limits.

F. Peer Computer Control Software: Shall detect a failure of workstation and associated server and shall cause other workstation and associated server to assume control of all system functions without interruption of operation. Drivers shall be provided in both central computers to support this mode of operation.

2.5 APPLICATIONS SOFTWARE

A. Basic Requirements:
   1. Fully compatible with and based on the approved operating system.
   2. Password-protected operator login and access; three levels, minimum.
   3. Password-protected setup functions.
   4. Context sensitive on-line help.
   5. Capability of creating, deleting, and copying files; and automatically maintaining a directory of all files, including size and location of each sequential and random- ordered record.
   6. Capability for importing custom icons into graphic views to represent alarms and I/O devices.
   7. Automatic and encrypted backups for database and history; automatically stored at central control PC and encrypted with a nine-character alphanumeric password, which must be used to restore or read data contained in backup.
   8. Operator audit trail for recording and reporting all changes made to user-defined system options.

B. Workstation Server Functions:
   1. Support other client PCs on the LAN and WAN.
   2. Maintain recorded data in databases accessible from other PCs on the LAN and WAN.

C. Data Formats:
   1. User-programmable export and import of data to and from commonly used Microsoft Windows spreadsheet, database, billing, and other applications; using dynamic data exchange technology.
   2. Option to convert reports and graphics to HTML format.
   3. Interactive graphics.

4. Option to send preprogrammed or operator designed e-mail reports.

D. Metered Data: Display metered values in real time.

E. Remote Control:
1. Display circuit-breaker status and allow breaker control.
2. User defined with load-shedding automatically initiated and executed schemes responding to programmed time schedules, set points of metered demands, utility contracted load shedding, or combinations of these.

F. Equipment Documentation: Database for recording of equipment ratings and characteristics; with capability for graphic display on monitors.

G. Graphics: Interactive color-graphics platform with pull-down menus and mouse-driven generation of power system graphics, in formats widely used for such drafting; to include the following:
1. Site plan.
2. Floor plans.
3. Equipment elevations.
4. Single-line diagrams.

H. User-Defined Monitoring and Control Events: Display and record with date and time stamps accurate to 0.1 second, and including the following:
1. Operator log on/off.
2. Attempted operator log on/off.
3. All alarms.
4. Equipment operation counters.
5. Out-of-limit, pickup, trip, and no-response events.

I. Trending Reports: Display data acquired in real-time from different meters or devices, in historical format over user-defined time; unlimited as to interval, duration, or quantity of trends.
1. Spreadsheet functions of sum, delta, percent, average, mean, standard deviation, and related functions applied to recorded data.
2. Charting, statistical, and display functions of standard Windows-based spreadsheet.

J. Alarms: Display and record alarm messages from discrete input and controls outputs, according to user programmable protocol.
1. Functions requiring user acknowledgment shall run in background during computer use for other applications and override other presentations when they occur.

K. Waveform Data: Display and record waveforms on demand or automatically on an alarm or programmed event; include the graphic displays of the following, based on user-specified criteria:
1. Phase voltages, phase currents, and residual current.
2. Overlay of three-phase currents, and overlay each phase voltage and current.
3. Waveforms ranging in length from 2 cycles to 5 minutes.
4. Disturbance and steady-state waveforms up to 512 points per cycle.
5. Transient waveforms up to 83,333 points per cycle on 60-Hz base.
6. Calculated waveform on a minimum of four cycles of data of the following:
a. THD.
b. rms magnitudes. c. Peak values.
d. Crest factors.
e. Magnitude of individual harmonics.

L. Data Sharing: Allow export of recorded displays and tabular data to third-party applications software.

M. Tenant or Activity Billing Software:
1. Automatically compute and prepare tenant bills based on metering of energy use and peak demand integrated over user-defined interval.
2. Intervals shall be same as used by electric utilities, including current vendor.
3. Import metered data from saved records that were generated by metering and monitoring software.
4. Maintain separate directory for each tenant's historical billing information.
5. Prepare summary reports in user-defined formats and time intervals.

N. Reporting: User commands initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
1. Print a record of user-defined alarm, supervisory, and trouble events on workstation printer.

2. Sort and report by device name and by function.
3. Report type of signal (alarm, supervisory, or trouble), description, date, and time of occurrence.
4. Differentiate alarm signals from other indications.
5. When system is reset, report reset event with same information concerning device, location, date, and time.

2.6 COMMUNICATION COMPONENTS AND NETWORKS

A. Transient Voltage Surge Suppression and Electromagnetic-Interference Immunity: Include in solid-state equipment. Comply with IEEE C37.90.

B. Network Configuration: High-speed, multi-access, open nonproprietary, industry standard communication protocol; LANs complying with EIA 485, 100 Base-T Ethernet, and Modbus TCP/IP.

2.7 POWER MONITORS

A. Separately mounted, permanently installed instrument for power monitoring and control.
1. Enclosure: NEMA 250, Type 1

B. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
1. Indoor installation in nontemperature-controlled spaces that have environmental controls to maintain ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.

C. rms Real-Time Measurements:
1. Current: Each phase, neutral, average of three phases, percent unbalance.
2. Voltage: Line-to-line each phase, line-to-line average of three phases, line-to- neutral each phase, line-to-neutral average of three phases, line-to-neutral percent unbalance.
3. Power: Per phase and three-phase total.
4. Reactive Power: Per phase and three-phase total.
5. Apparent Power: Per phase and three-phase total.
6. Power Factor: Per phase and three-phase total.
7. Displacement Power Factor: Per phase and three-phase total.
8. Frequency.
9. THD: Current and voltage.
10. Accumulated Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
11. Incremental Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
12. Conditional Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).

D. Demand Current Calculations, per Phase, Three-Phase Average and Neutral:
1. Present.
2. Running average.
3. Last completed interval.
4. Peak.

E. Demand Real Power Calculations, Three-Phase Total:
1. Present.
2. Running average.
3. Last completed interval.
4. Predicted.
5. Peak.
6. Coincident with peak kVA demand.
7. Coincident with kVAR demand.

F. Demand Reactive Power Calculations, Three-Phase Total:
1. Present.
2. Running average.
3. Last completed interval.
4. Predicted.
5. Peak.
6. Coincident with peak kVA demand.
7. Coincident with kVAR demand.

G. Demand Apparent Power Calculations, Three-Phase Total:
   1. Present.
   2. Running average.
   3. Last completed interval.
   4. Predicted.
   5. Peak.
   6. Coincident with peak kVA demand.
   7. Coincident with kVAR demand.

H. Average Power Factor Calculations, Demand Coincident, Three-Phase Total:
   1. Last completed interval.
   2. Coincident with kW peak.
   3. Coincident with kVAR peak.
   4. Coincident with kVA peak.

I. Power Analysis Values:
   1. THD, Voltage and Current: Per phase, three phase, and neutral.
   2. Displacement Power Factor: Per phase, three phase.
   3. Fundamental Voltage, Magnitude and Angle: Per phase.
   4. Fundamental Currents, Magnitude and Angle: Per phase.
   5. Fundamental Real Power: Per phase, three phase.
   6. Fundamental Reactive Power: Per phase.
   7. Harmonic Power: Per phase, three phase.
   8. Phase rotation.
   9. Unbalance: Current and voltage.
   10. Harmonic Magnitudes and Angles for Current and Voltages: Per phase, up to 31st harmonic.

J. Power Demand Calculations: According to one of the following calculation methods, selectable by the user:
   1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
   2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
      a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
      b. Fixed block that calculates demand at end of the interval.
      c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
   3. Demand Calculation Initiated by a Synchronization Signal:
      a. Signal is a pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.
      b. Signal is a communication signal. Calculation shall be configurable as either a block or rolling block calculation.
      c. Demand can be synchronized with clock in the power meter.

K. Sampling:
   1. Current and voltage shall be digitally sampled at a rate high enough to provide accuracy to 63rd harmonic of 60-Hz fundamental.
   2. Power monitor shall provide continuous sampling at a rate of 128 samples per cycle on all voltage and current channels in the meter.

L. Minimum and Maximum Values: Record monthly minimum and maximum values, including date and time of record. For three-phase measurements, identify phase of recorded value. Record the following parameters:
   1. Line-to-line voltage.
   2. Line-to-neutral voltage.
   3. Current per phase.
   4. Line-to-line voltage unbalance.
   5. Line-to-neutral voltage unbalance.

6. Power factor.
7. Displacement power factor.
8. Total power.
9. Total reactive power.
10. Total apparent power.
11. THD voltage L-L.
12. THD voltage L-N.
13. THD current.
14. Frequency.

M. Harmonic Calculation: Display and record the following:
1. Harmonic magnitudes and angles for each phase voltage and current through 31st harmonic. Calculate for all three phases, current and voltage, and residual current. Current and voltage information for all phases shall be obtained simultaneously from same cycle.
2. Harmonic magnitude reported as a percentage of the fundamental or as a percentage of rms values, as selected by user.

N. Current and Voltage Ratings:
1. Designed for use with current inputs from standard instrument current transformers with 5-A secondary and shall have a metering range of 0-10 A.
2. Withstand ratings shall be not less than 15 A, continuous; 50 A, lasting over 10 seconds, no more frequently than once per hour; 500 A, lasting 1 second, no more frequently than once per hour.
3. Designed for use with voltage inputs from standard instrument potential transformers with a 120-V secondary.

O. Accuracy:
1. Comply with ANSI C12.20, Class 0.5; and IEC 60687, Class 0.5 for revenue meters.
2. Accuracy from Light to Full Rating:
a. Power: Accurate to 0.25 percent of reading, plus 0.025 percent of full scale.
b. Voltage and Current: Accurate to 0.075 percent of reading, plus 0.025 percent of full scale.
c. Power Factor: Plus or minus 0.002, from 0.5 leading to 0.5 lagging. d. Frequency: Plus or minus 0.01 Hz at 45 to 67 Hz.

P. Waveform Capture:
1. Capture and store steady-state waveforms of voltage and current channels; initiated manually. Each capture shall be for 3 cycles, 128 data points for each cycle, allowing resolution of harmonics to 31st harmonic of basic 60 Hz.
2. Store captured waveforms in internal nonvolatile memory; available for PC display, archiving, and analysis.

Q. Input: One digital input signal(s).
1. Normal mode for on/off signal.
2. Demand interval synchronization pulse, accepting a demand synchronization pulse from a utility demand meter.
3. Conditional energy signal to control conditional energy accumulation.

R. Outputs:
1. Operated either by user command sent via communication link, or set to operate in response to user-defined alarm or event.
2. Closed in either a momentary or latched mode as defined by user.
3. Each output relay used in a momentary contact mode shall have an independent timer that can be set by user.
4. One digital KY pulse to a user-definable increment of energy measurement. Output ratings shall be up to 120-V ac, 300-V dc, 50 mA, and provide 3500-V rms isolation.
5. One relay output module(s), providing a load voltage range from 20- to 240-V ac or from 20- to 30-V dc, supporting a load current of 2 A.
6. Output Relay Control:
a. Relay outputs shall operate either by user command sent via communication link or in response to user-defined alarm or event.
b. Normally open and normally closed contacts, field configured to operate as follows:

1) Normal contact closure where contacts change state for as long as signal exists.
2) Latched mode when contacts change state on receipts of a pickup signal; changed state is held until a dropout signal is received.
3) Timed mode when contacts change state on receipt of a pickup signal; changed state is held for a preprogrammed duration.
4) End of power demand interval when relay operates as synchronization pulse for other devices.
5) Energy Pulse Output: Relay pulses quantities used for absolute kWh, absolute kVARh, kVAh, kWh In, kVARh In, kWh Out, and kVARh Out.
6) Output controlled by multiple alarms using Boolean-type logic.

S. Onboard Data Logging:
1. Store logged data, alarms, events, and waveforms in 80 KB of onboard nonvolatile memory.
2. Stored Data:
a. Billing Log: User configurable; data shall be recorded every 15 minutes, identified by month, day, and 15-minute interval. Accumulate 24 months of monthly data, 32 days of daily data, and between 2 to 52 days of 15-minute interval data, depending on number of quantities selected.
b. Custom Data Logs: Three user-defined log(s) holding up to 96 parameters.
Date and time stamp each entry to the second and include the following user definitions:
1) Schedule interval.
2) Event definition.
3) Configured as "fill-and-hold" or "circular, first-in first-out."
c. Alarm Log: Include time, date, event information, and coincident information for each defined alarm or event.
d. Waveform Log: Store captured waveforms configured as "fill-and-hold" or circular, first-in first-out."
3. Default values for all logs shall be initially set at factory, with logging to begin on device power up.

T. Alarms.
1. User Options:
a. Define pickup, dropout, and delay.
b. Assign one of four severity levels to make it easier for user to respond to the most important events first.
c. Allow for combining up to four alarms using Boolean-type logic statements for outputting a single alarm.
2. Alarm Events:
a. Over/undercurrent.
b. Over/undervoltage.
c. Current imbalance.
d. Phase loss, current.
e. Phase loss, voltage.
f. Voltage imbalance.
g. Over kW demand.
h. Phase reversal.
i. Digital input off/on.
j. End of incremental energy interval.
k. End of demand interval.

U. Control Power: 90- to 457-V ac or 100- to 300-V dc. V. Communications:
1. Power monitor shall be permanently connected to communicate via Modbus TCP via a 100 Base-T Ethernet.
2. Local plug-in connections shall be for RS-232 and 100 Base-T Ethernet.

W. Display Monitor:
1. Backlighted LCD to display metered data with touch-screen selecting device.
2. Touch-screen display shall be a minimum 12-inch diagonal, resolution of 800 by 600 RGB pixels, 256 colors; NEMA 250, Type 1 display enclosure.
3. Display four values on one screen at same time.
a. Current, per phase rms, three-phase average and neutral.
b. Voltage, phase to phase, phase to neutral, and three-phase averages of phase to phase and phase to neutral.

c. Real power, per phase and three-phase total.
d. Reactive power, per phase and three-phase total.
e. Apparent power, per phase and three-phase total.
f. Power factor, per phase and three-phase total.
g. Frequency.
h. Demand current, per phase and three-phase average.
i. Demand real power, three-phase total.
j. Demand apparent power, three-phase total.
k. Accumulated energy (MWh and MVARh).
l. THD, current and voltage, per phase.

4. Reset: Allow reset of the following parameters at the display:
   a. Peak demand current.
   b. Peak demand power (kW) and peak demand apparent power (kVA). c. Energy (MWh) and reactive energy (MVARh).

2.8 STANDALONE, WEB-ENABLED MONITORING AND CONTROL INSTRUMENT

A. Separately mounted, permanently installed instrument for power monitoring and control.
   1. Enclosure: NEMA 250, Type 1.

B. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability.
   1. Indoor installation in nontemperature-controlled spaces that have environmental controls to maintain ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.

C. Power-Distribution Equipment Monitor: Web enabled, with integral network port and embedded Web server with factory-configured firmware and HTML-formatted Web pages for viewing of power monitoring and equipment status information from connected devices equipped with digital communication ports.

D. LAN Connectivity: Multipoint, RS-485 Modbus serial communication network, interconnecting all breaker trip units, protective relays, drives, and metering devices equipped with communications. Serial communication network connected to Ethernet server that functions as a gateway and server, providing data access via 100 Base-T LAN.

E. Communication Devices within the Equipment: Addressed at factory and tested to verify reliable communication with network server.

F. Server Configuration:
   1. Initial network parameters set using a standard Web browser. Connect via a local operator interface, or an RJ-45 port accessible from front of equipment.
   2. Network server shall be factory programmed with embedded HTML-formatted Web pages that are user configurable and that provide detailed communication diagnostic information for serial and Ethernet ports as status of RS-485 network; with internal memory management information pages for viewing using a standard Web browser.
   3. Login: Password protected; password administration accessible from the LAN using a standard Web browser.
   4. Operating Software: Suitable for local access; firewall protected.

G. Data Access:
   1. Network server shall include embedded HTML pages providing real-time information from devices connected to RS-485 network ports via a standard Web browser.

H. Equipment Monitoring Options: Login shall be followed by a main menu for selecting summary Web pages that follow.

I. Summary Web pages shall be factory configured to display the following information for each communicating device within the power equipment lineup:
   1. User-Configured Custom Home Page: Provide for the lineup, showing status-at- a-glance of key operating values.
   2. Circuit Summary Page: Circuit name, three-phase average rms current, power (kW), power factor, and breaker status.
   3. Load Current Summary Page: Circuit name, Phase A, B, and C rms current values.
   4. Demand Current Summary Page: Circuit name, Phase A, B, and C average demand current values.

5. Power Summary Page: Circuit name, present demand power (kW), peak demand power (kW), and recorded time and date.
6. Energy Summary Page: Circuit name, energy (kWh), reactive energy (kVARh), and time/date of last reset.
7. Transformer Status Page: Transformer tag, coil temperatures, and cooling fan status.
8. Motor-Control Center Status Page: Circuit name, three-phase average rms current, thermal capacity (percentage), and drive output frequency (Hz) contactor status.
9. Specific Device Pages: Each individual communicating device shall display detailed, real-time information, as appropriate for device type.
   a. Display historical energy data that shall be logged automatically for each device, as appropriate for device type.
   b. Display historical data logged from each device in graphical time-trend plots. Value to be displayed on time-trend plot shall be user selectable. Time interval to be displayed on scale shall be for previous day or week.
10. Export historical energy data to a PC or workstation through network using FTP (File Transfer Protocol). Format exported data in a CSV (Comma Separated Variable) file format for importing into spreadsheet applications.

J. Communications:
   1. Power monitor: Permanently connected to communicate via RS-485 Modbus
   1. TCP/IP.
   2. Local Plug-in Connections: RS-232 and 100 Base-T Ethernet.
   3. Monitor Display: Backlighted LCD to display metered data with touch-screen selecting device.

2.9 WORKSTATION HARDWARE

A. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   1. Indoor installation in spaces that have environmental controls to maintain ambient conditions of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.

B. Computer: Standard unmodified PC of modular design. CPU word size shall be 32 bytes or larger; CPU operating speed shall be at least 66.
   1. Memory: 256 MB of usable installed memory, expandable to a minimum of 1024 MB without additional chassis or power supplies.
   2. Real-Time Clock:
      a. Accuracy: Plus or minus 1 minute per month.
      b. Time Keeping Format: 24-hour time format including seconds, minutes, hours, date, day, and month; automatic reset by software.
      c. Clock shall function for one year without power.
      d. Provide automatic time correction once every 24 hours by synchronizing clock with the Time Service Department of the U.S. Naval Observatory.
   3. Serial Ports: Two RS-232-F serial ports for general use, with additional ports as required. Data transmission rates shall be selectable under program control.
   4. Parallel Port: Enhanced.
   5. LAN Adapter Card: 10/100-Mbps PCI bus, internal network interface card.
   6. Sound Card: For playback and recording of digital WAV sound files associated with audible warning and alarm functions.
   7. Color Monitor: PC compatible, not less than 18 inches, LCD type, with a minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch of 0.28 mm.
   8. Keyboard: Minimum of 64 characters, standard ASCII character set based on ANSI INCITS 154.
   9. Mouse: Standard, compatible with installed software.
   10. Disk Storage: Include the following, each with appropriate controller:
      a. Minimum 80- GB hard disk, maximum average access time of 10 ms.
      b. Floppy Disk Drive: High density, 3-1/2-inch size.
      c. PCMCIA slot with removable 500-MB media.
      d. 100 -MB Iomega Zip drive.
      e. 250-MB Iomega Jaz drive.
   11. Audible Alarm: Manufacturer's standard.
   12. CD-ROM Drive:

a. Nominal Storage Capacity: 650 MB.
b. Data Transfer Rate: 1.2 Mbps.
c. Average Access Time: 150 ms.
d. Cache Memory: 256 KB.
e. Data Throughput: 1 MB/second, minimum.

13. Report Printer: Minimum resolution 600 dpi laser printer.
    a. Connected to central station and designated workstations.
    b. RAM: 2 MB, minimum.
    c. Printing Speed: Minimum 12 pages per minute.
    d. Paper Handling: Automatic sheet feeder with 250-sheet paper cassette and with automatic feed.
14. Interface: Bidirectional parallel and universal serial bus.
15. LAN Adapter Card: 10/100 -Mbps internal network interface card.

C. Redundant Central Computer: Connected in a hot standby, peer configuration; automatically maintains copies of system software, application software, and data files. System transactions and other activities that alter system data files shall be updated to system files of redundant computer in near real-time. If central computer fails, redundant computer shall assume control immediately and automatically.

D. UPS: Self-contained; complying with requirements in Division 26 Section "Static Uninterruptible Power Supply."
1. Size: Provide a minimum of 6 hours of operation of workstation station equipment, including 2 hours of alarm printer operation.
2. Batteries: Sealed, valve regulated, recombinant, lead calcium.
3. Accessories:

a. Transient voltage suppression.
b. Input-harmonics reduction.
c. Rectifier/charger.
d. Battery disconnect device.
e. Static bypass transfer switch.
f. Internal maintenance bypass/isolation switch.
g. External maintenance bypass/isolation switch.
h. Output isolation transformer.
i. Remote UPS monitoring.
j. Battery monitoring.
k. Remote battery monitoring.

2.10 RS-232 ASCII INTERFACE

A. ASCII interface shall allow RS-232 connections to be made between a meter or circuit monitor operating as the host PC and any equipment that will accept RS-232 ASCII command strings, such as local display panels dial-up modems and alarm transmitters.

B. Pager System Interface: Alarms shall be able to activate a pager system with customized message for each input alarm.
1. RS-232 output shall be capable of connection to a pager interface that can be used to call a paging system or service and send a signal to a portable pager. System shall allow an individual alphanumeric message per alarm input to be sent to paging system. This interface shall support both numeric and alphanumeric pagers.

C. Alarm System Interface:
1. RS-232 output shall be capable of transmitting alarms from other monitoring and alarm systems to workstation software.

D. Cables:
1. PVC-Jacketed, RS-232 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum foil- polyester tape shielded pairs with 100 percent shield coverage; PVC jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
    a. CBC, Type CM.
    b. Flame Resistance: UL 1581, Vertical Tray.

2. Plenum-Type, RS-232 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil- polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
   a. CBC, Type CMP.
   b. Flame Resistance: NFPA 262, Flame Test.

2.11 LAN CABLES

A. Comply with Division 27 Section "Communications Horizontal Cabling."

B. RS-485 Cable:
   1. PVC-Jacketed, RS-485 Cable: Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, PVC insulation, unshielded, PVC jacket, and NFPA 70, Type CMG.
   2. Plenum-Type, RS-485 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and fluorinated-ethylene-propylene jacket, and NFPA 70, Type CMP.

C. Unshielded Twisted Pair Cables: Category 6 as specified for horizontal cable for data service in Division 27 Section "Communications Horizontal Cabling."

2.12 LOW-VOLTAGE WIRING

A. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.
   1. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
   2. Ordinary Switching Circuits: Three conductors, unless otherwise indicated.
   3. Switching Circuits with Pilot Lights or Locator Feature: Five conductors, unless otherwise indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
   1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CABLING

A. Comply with NECA 1.

B. Install cables and wiring according to requirements in Division 27 Section "Communications Horizontal Cabling."

C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

D. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.

E. Install LAN cables using techniques, practices, and methods that are consistent with specified category rating of components and that ensure specified category performance of completed and linked signal paths, end to end.

F. Install cables without damaging conductors, shield, or jacket.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification For Electrical Systems."

B. Label each power monitoring and control module with a unique designation.

3.4 GROUNDING

A. Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:
   1. Electrical Tests: Use caution when testing devices containing solid-state components.
   2. Continuity tests of circuits.
   3. Operational Tests: Set and operate controls at workstation and at monitored and controlled devices to demonstrate their functions and capabilities. Use a methodical sequence that cues and reproduces actual operating functions as recommended by manufacturer. Submit sequences for approval. Note response to each test command and operation. Note time intervals between initiation of alarm conditions and registration of alarms at central-processing workstation.
      a. Coordinate testing required by this Section with that required by Sections specifying equipment being monitored and controlled.
      b. Test LANs according to requirements in Division 27 Section "Communications Horizontal Cabling."
      c. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of calculated battery operating time.
      d. Verify accuracy of graphic screens and icons.
      e. Metering Test: Load feeders, measure loads on feeder conductor with an rms reading clamp-on ammeter, and simultaneously read indicated current on the same phase at central-processing workstation. Record and compare values measured at the two locations. Resolve discrepancies greater than 5 percent and record resolution method and results.
      f. Record metered values, control settings, operations, cues, time intervals, and functional observations and submit test reports printed by workstation printer.

E. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

F. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

G. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

H. Remove and replace malfunctioning devices and circuits and retest as specified above.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems. Refer to Division 01 Section "Demonstration and Training."
   1. Train Owner's management and maintenance personnel in interpreting and using monitoring displays and in configuring and using software and reports. Include troubleshooting, servicing, adjusting, and maintaining equipment. Provide a minimum of 12 hours' training.
   2. Training Aid: Use approved final versions of software and maintenance manuals as training aids.

3.7 ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION

LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following lighting control devices:
   1. Time switches.
   2. Outdoor and indoor photoelectric switches.
   3. Indoor occupancy sensors.
   4. Outdoor motion sensors.
   5. Lighting contactors.
   6. Emergency shunt relays.

B. Related Sections include the following:
   1. Division 26 Sections “Central Dimming Controls” for architectural dimming system equipment.
   2. Division 26 Section "Network Lighting Controls" for low-voltage, manual and programmable lighting control systems.
   3. Division 26 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Show installation details for occupancy and light-level sensors.
   1. Interconnection diagrams showing field-installed wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   1. Lutron
   2. Area Lighting Research, Inc.; Tyco Electronics.
   3. Grasslin Controls Corporation; a GE Industrial Systems Company.
   4. Intermatic, Inc.
   5. Leviton Mfg. Company Inc.
   6. Lightolier Controls; a Genlyte Company.
   7. Lithonia Lighting; Acuity Lighting Group, Inc.
   8. Paragon Electric Co.; Invensys Climate Controls.

9. Square D; Schneider Electric.
10. TORK.
11. Watt Stopper (The).
12. Lutron

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. Lutron
2. Grasslin Controls Corporation; a GE Industrial Systems Company.
3. Intermatic, Inc.
4. Lithonia Lighting; Acuity Lighting Group, Inc.
5. Novitas, Inc.
6. Paragon Electric Co.; Invensys Climate Controls.
7. Square D; Schneider Electric.
8. TORK.
9. Touch-Plate, Inc.
10. Watt Stopper (The).

D. Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
2. Time Delay: 15-second minimum, to prevent false operation.
3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

E. Description: Solid state, with SPST dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.
1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
2. Time Delay: 30-second minimum, to prevent false operation.
3. Lightning Arrester: Air-gap type.
4. Mounting: Twist lock complying with IEEE C136.10, with base.

2.3 INDOOR PHOTOELECTRIC SWITCHES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawingsor a comparable product by one of the following:
1. ETC
2. Leviton
3. Hubbell
4. Lutron
5. Sensorswitch
6. Intermatic, Inc.
7. Lithonia Lighting; Acuity Lighting Group, Inc.
8. MicroLite Lighting Control Systems.
9. Novitas, Inc.
10. Paragon Electric Co.; Invensys Climate Controls.
11. Square D; Schneider Electric.
12. TORK.
13. Touch-Plate, Inc.

14. Watt Stopper (The).

D. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with separate relay unit to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.
   1. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
   2. Relay Unit: Dry contacts rated for 20 -A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
   3. Light-Level Monitoring Range: 10 to 200 fc, with an adjustment for turn-on and turn-off levels within that range.
   4. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
   5. Indicator: Two LEDs to indicate the beginning of on-off cycles.

2.4 INDOOR OCCUPANCY SENSORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   1. Lutron
   2. Hubbell Lighting.
   3. Leviton Mfg. Company Inc.
   4. Lithonia Lighting; Acuity Lighting Group, Inc.
   5. Sensor Switch, Inc.
   6. Watt Stopper (The).

D. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
   1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
   2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
   3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
   4. Mounting:
      a. Sensor: Suitable for mounting in any position on a standard outlet box.
      b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
      c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
   5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
   6. Bypass Switch: Override the on function in case of sensor failure.
   7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; keep lighting off when selected lighting level is present.

E. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.
   1. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in..
   2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
   3. Detection Coverage (Corridor): Detect occupancy within 90 feet when mounted on a 10-foot- high ceiling.

F. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage. To be used in multi-stall restrooms.
   1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.

2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. when mounted on a 96-inch- high ceiling.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. when mounted on a 96-inch- high ceiling.
5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet when mounted on a 10-foot- high ceiling in a corridor not wider than 14 feet.

G. Dual-Technology Type: Typical type to be used throughout. Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

2.5 OUTDOOR MOTION SENSORS (PIR)

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. Lutron
2. Leviton
3. Sensorswitch
4. Bryant Electric; a Hubbell Company.
5. Hubbell Lighting.
6. Lithonia Lighting; Acuity Lighting Group, Inc.
7. Paragon Electric Co.; Invensys Climate Controls.
8. RAB Lighting, Inc.
9. TORK.
10. Watt Stopper (The).

D. Performance Requirements: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F, rated as raintight according to UL 773A.
1. Operation: Turn lights on when sensing infrared energy changes between background and moving body in area of coverage; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
2. Mounting:
a. Sensor: Suitable for mounting in any position on a standard outdoor junction box.
b. Relay: Internally mounted in a standard weatherproof electrical enclosure.
c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
3. Bypass Switch: Override the on function in case of sensor failure.
4. Automatic Light-Level Sensor: Adjustable from 1 to 20 fc; keep lighting off during daylight hours.

E. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in..

F. Detection Coverage: Up to 35 feet, with a field of view of 180 degrees

G. Lighting Fixture Mounted Sensor: Suitable for switching 300 W of tungsten load at 120- or 277-V ac.

H. Individually Mounted Sensor: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
1. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.

2. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.

2.6 LIGHTING CONTACTORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. Lutron
2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
3. Eaton Electrical Inc.; Cutler-Hammer Products.
4. GE Industrial Systems; Total Lighting Control.
5. Hubbell Lighting.
6. Lithonia Lighting; Acuity Lighting Group, Inc.
7. MicroLite Lighting Control Systems.
8. Square D; Schneider Electric.
9. TORK.
10. Watt Stopper (The).

D. Description: Electrically operated and mechanically held, combination type, complying with NEMA ICS 2 and UL 508.
1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.7 EMERGENCY SHUNT RELAY

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide Lutron.

D. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.
1. Coil Rating: 120V.

2.8 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch.

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
   1. Identify controlled circuits in lighting contactors.
   2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
   2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Network Lighting Controls."

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

SECONDARY UNIT SUBSTATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes indoor and outdoor secondary unit substations, each consisting of the following:
   1. Primary incoming section.
   2. Transformer.
   3. Secondary distribution section.

B. Related Sections include the following:
   1. Division 26 Section "Medium-Voltage Cables" for requirements of terminating cables in incoming section of substation.
   2. Division 26 Section "Overcurrent Protective Device Coordination Study" for short-circuit rating of devices and for setting of overcurrent protective devices.
   3. Division 26 Section "Electrical Power Monitoring and Control" for communication features of power distribution system devices.
   4. Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits" for transient voltage surge suppressors for low-voltage power, control, and communication equipment that may be located in secondary section.

1.3 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Wiring Diagrams: Power, signal, and control wiring.
   2. Dimensioned plans and elevations showing major components and features.
   3. One-line diagram.
   4. List of materials.
   5. Nameplate legends.
   6. Size and number of bus bars and current rating for each bus, including mains and branches of phase, neutral, and ground buses.
   7. Short-time and short-circuit current ratings of secondary unit substations and components.
   8. Ratings of individual protective devices.

C. Time-Current Characteristic Curves: For overcurrent protective devices.

D. Primary Fuses: Submit recommendations and size calculations.

E. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Dimensioned concrete base, outline of secondary unit substation, conduit entries, and ground rod locations.
   2. Location of structural supports for structure-supported raceways, busways, and seismic bracing.
   3. Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.

F. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
      b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Product Certificates: For secondary unit substations, signed by product manufacturer.

H. Qualification Data: For testing agency.

I. Material Test Reports: For secondary unit substations.

J. Factory test reports.

K. Field quality-control test reports.

L. Operation and Maintenance Data: For secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain secondary unit substation through one source from a single manufacturer.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of secondary unit substations and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

D. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with IEEE C2.

F. Comply with IEEE C37.121.

G. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate delivery of secondary unit substations to allow movement into designated space.

C. Store secondary unit substation components[protected from weather and] so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

D. Handle secondary unit substation components according to manufacturer's written instructions. Use factory-installed lifting provisions.

1.7 PROJECT CONDITIONS

A. Field Measurements: Indicate measurements on Shop Drawings.

B. Interruption of Existing electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.

C. Service Conditions: IEEE C37.121, usual service conditions, except for the following:
1. Exposure to significant solar radiation.
2. Altitudes above 3300 feet.
3. Exposure to fumes, vapors, or dust.
4. Exposure to explosive environments.
5. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
6. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
7. Exposure to excessively high or low temperatures.

8. Unusual transportation or storage conditions.
9. Unusual grounding resistance conditions.
10. Unusual space limitations.

1.8 COORDINATION

A. Coordinate layout and installation of secondary unit substations with other construction that penetrates floors and ceilings, or is supported by them, including light fixtures, HVAC equipment, and fire-suppression-system components.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Spare fuses: Six of each type and rating of fuse and fusible device used. Include spares for the following:
a. Primary disconnect fuses.
b. Potential transformer fuses.
c. Control power fuses.
d. Fuses and fusible devices for fused circuit breakers.
e. Fuses for secondary fusible devices.
2. Spare Indicating Lights: Six of each type installed.
3. Touchup Paint: Three half-pint containers of paint matching enclosure's exterior finish.
4. Primary Switch Contact Lubricant: One container(s).
5. One set of spare mounting gaskets for bushings, handholes, and the gasket between relief cover and flange of pressure relief device.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB Control, Inc.
2. Cooper Industries, Inc.; Cooper Power Systems Division.
3. Cutler-Hammer.
4. GE Electrical Distribution and Control.
5. Siemens Energy and Automation, Inc.
6. Square D; Schneider Electric.

2.2 MANUFACTURED UNITS

A. Indoor Unit Arrangement: Single assembly.

B. Indoor Unit Arrangement: Separate secondary distribution equipment connected with busway.

C. Enclosure Finish: Factory-applied finish in manufacturer's standard color, including under surfaces treated with corrosion-resistant undercoating.

D. Enclosure Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.3 INCOMING SECTION

A. Primary Incoming Section: Terminal assembly with adequate space for incoming-cable terminations and surge arresters.

B. Primary Incoming Section: Transformer cover-mounted bushings.

C. Surge Arresters: Comply with IEEE C62.11, Distribution class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device.

2.4 DRY-TYPE TRANSFORMER SECTION

A. Description: IEEE C57.12.01, IEEE C57.12.52, NEMA ST 20, and dry-type, 2-winding, secondary unit substation transformer.

B. Enclosure: Indoor, ventilated, cast coil/encapsulated coil, with primary and secondary copper windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.

C. Cooling System: Class AA, air cooled, complying with IEEE C57.12.01.
   1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.
   2. Include mounting provision for fans.

D. Insulation Materials: IEEE C57.12.01, rated 220 deg C.

E. Insulation Temperature Rise: 80 deg C, maximum rise above 40 deg C.

F. Basic Impulse Level: 95 kV.

G. Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps, 2 above and 2 below rated primary voltage.

H. Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps below rated primary voltage.

I. Sound level may not exceed 64 dBA level, without fans operating.

J. Impedance: 5 percent.

K. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

2.5 SECONDARY DISTRIBUTION SECTION

A. Secondary Terminal Compartment: Bus duct flange for close coupling with busway.

B. Secondary Distribution: Low-voltage switchboard as specified in Division 26 Section "Switchboards."

C. Distribution Panelboard: Panelboards as specified in Division 26 Section "Panelboards."

2.6 IDENTIFICATION DEVICES

A. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.7 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90. Conduct switchgear and switchboard tests according to ANSI C37.51.

B. Factory Tests: Perform the following factory-certified tests on each secondary unit substation:
   1. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.
   2. Ratios on the rated voltage connection and on tap extreme connections.
   3. Polarity and phase relation on the rated voltage connection.
   4. No-load loss at rated voltage on the rated voltage connection.
   5. Exciting current at rated voltage on the rated voltage connection.
   6. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.
   7. Applied potential.
   8. Induced potential.
   9. Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class FA rating.
      a. Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.
   10. Owner will witness all required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of work.

B. Examine roughing-in of conduits and grounding systems to verify the following:
   1. Wiring entries comply with layout requirements.
   2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit substation installation.

D. Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at secondary unit substation location.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install secondary unit substations on concrete bases.
   1. Anchor secondary unit substations to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 26 Sections "Hangers and Supports for Electrical Systems" and "Vibration and Seismic Controls for Electrical Systems."
   2. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit and 4 inches high.
   3. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."
   4. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
   5. Install epoxy-coated anchor bolts for anchoring equipment to the concrete base.
   6. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   7. Bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

B. Operating Instructions: Frame printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of secondary unit substation.

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Testing: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

C. Testing: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

D. Perform the following field tests and inspections and prepare test reports:

1. Perform each visual and mechanical inspection and electrical test according to NETA ATS. Certify compliance with test parameters.
2. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation tested at the specified value or less.
3. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
4. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
    a. Remove and replace malfunctioning units and retest as specified above.

3.7 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:
    1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each secondary unit substation. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
    2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
        a. Adjust transformer taps.
        b. Rebalance loads.
        c. Prepare written request for voltage adjustment by electric utility.
    3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
    4. Report: Prepare a written report covering monitoring performed and corrective action taken.

B. Infrared Scanning: Perform as specified in Division 26 Section "Medium-Voltage Switchgear."

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
   1. Distribution transformers.
   2. Buck-boost transformers.

1.3 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Wiring Diagrams: Power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
      b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: For testing agency.

E. Source quality-control test reports.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

C. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.5 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.6 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Siemens Energy and Automation, Inc.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.
1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Copper.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated, NEMA 250, Type 2.
1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

E. Enclosure: Ventilated, NEMA 250.
1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

F. Transformer Enclosure Finish: Comply with NEMA 250.
1. Finish Color: [Gray] [ANSI 49 gray] [ANSI 61 gray].

G. Taps for Transformers Smaller Than 3 kVA: None.

H. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

I. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

J. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

K. Energy Efficiency for Transformers Rated 15 kVA and Larger:
1. Complying with NEMA TP 1, Class 1 efficiency levels.
2. Tested according to NEMA TP 2.

L. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
2. Indicate value of K-factor on transformer nameplate.

M. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.

2. Include special terminal for grounding the shield.
3. Shield Effectiveness:
   a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
   b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
   c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.

N. Wall Brackets: Manufacturer's standard brackets.

O. Fungus Proofing: Permanent fungicidal treatment for coil and core.

P. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

Q. Low-Sound-Level Requirements: Maximum sound levels, when factory tested according to IEEE C57.12.91.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
   1. Brace wall-mounting transformers as specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instruction, and requirements in Division 26 Section "Hangers and Supports for Electrical Systems."

3.3 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

E. Remove and replace units that do not pass tests or inspections and retest as specified above.

F. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
   1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
   2. Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Substantial Completion.
   3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

G. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Service and distribution switchboards rated 600 V and less.
2. Surge Protection Device (SPD).
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.
8. Mimic bus.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.
1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.
7. Include evidence of NRTL listing for series rating of installed devices.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
10. Include diagram and details of proposed mimic bus.
11. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.

D. Qualification Data: For qualified Installer.

E. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Field Quality-Control Reports:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

G. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Routine maintenance requirements for switchboards and all installed components.
   2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on- site testing.

C. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in

CBC, by a qualified testing agency, and marked for intended location and application.

F. Comply with NEMA PB 2.

G. Comply with UL 891.

H. Comply with City of Chicago Building Code

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.

C. Handle and prepare switchboards for installation according to NECA 400.

1.7 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:
   1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

      a. Ambient Temperature: Not exceeding 104 deg F.
      b. Altitude: Not exceeding 6600 feet.

C. Service Conditions: NEMA PB 2, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet.

D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Architect no fewer than seven days in advance of proposed interruption of electric service.

2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Architect's written permission.
4. Comply with NFPA 70E.

1.8 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Five years from date of Substantial Completion.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type, but no fewer than one of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Siemens Energy and Automation, Inc.

B. Front-Connected, Front-Accessible Switchboards:
1. Main Devices: Panel mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

C. Front- and Side-Accessible Switchboards:
1. Main Devices: Panel mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

D. Nominal System Voltage: See drawings

E. Main-Bus Continuous: See drawings

F. Indoor Enclosures: Steel, NEMA 250, Type 1.

G. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

H. Barriers: Between adjacent switchboard sections.

I. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

J. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate

vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

K. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks. See section 26 09 13 “Electrical Power Monitoring and Control” for additional information.

L. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

M. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws for access to rear interior of switchboard.

N. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

O. Pull Box on Top of Switchboard:
1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Set back from front to clear circuit-breaker removal mechanism.
3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

P. Buses and Connections: Three phase, four wire unless otherwise indicated.
1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity
2. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
3. Ground Bus: Minimum-size required by UL 891 hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
4. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
5. Neutral Buses: 50 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
6. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
7. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

Q. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

R. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

S. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers

2.2 TRANSIENT VOLTAGE SUPPRESSION DEVICES

A. Manufacturers: Subject to compliance with requirements:

B. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer and Industrial - Electrical Distribution.
3. Siemens Energy and Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, bolt- on, solid-state, parallel-connected, modular (with field-replaceable modules)] type, with sine-wave tracking suppression

and filtering modules, UL 1449, second edition, short- circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:

1. Fuses, rated at 200-kA interrupting capacity.
2. Fabrication using bolted compression lugs for internal wiring.
3. Integral disconnect switch.
4. Redundant suppression circuits.
5. Redundant replaceable modules.
6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
7. LED indicator lights for power and protection status.
8. Audible alarm, with silencing switch, to indicate when protection has failed.
9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current- limiting device. Coordinate with building power monitoring and control system.
10. Four-digit, transient-event counter set to totalize transient surges.

D. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.

E. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

F. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 and 208Y/120 -V, three-phase, four-wire circuits shall be as follows:
1. Line to Neutral: 800 V for 480Y/277 and 400 V for 208Y/120
2. Line to Ground: 800 V for 480Y/277 and 400 V for 208Y/120
3. Neutral to Ground: 800 V for 480Y/277 and 400 V for 208Y/120

G. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:
1. Line to Neutral: 400 V, 800 V from high leg.
2. Line to Ground: 400 V.
3. Neutral to Ground: 400 V.

H. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:
1. Line to Line: 2000 V for 480 V and 1000 V for 240 V
2. Line to Ground: 2000 V for 480 V and 1000 V for 240 V

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front- mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I^2t response.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
6. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground- fault protection (6-mA trip).
7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground- fault protection (30-mA trip).
8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.

b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high- intensity discharge (HID) lighting circuits.
d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
f. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
i. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Insulated-Case Circuit Breaker (ICCB): 80 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
1. Fixed circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. Full-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
a. Instantaneous trip.
b. Long- and short-time time adjustments.
c. Ground-fault pickup level, time delay, and I^2t response.
4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
5. Remote trip indication and control.
6. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

D. Fuses are specified in Division 26 Section "Fuses."

2.4 INSTRUMENTATION

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
1. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, double secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound window type; double secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit- breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
a. Phase Currents, Each Phase: Plus or minus 1 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent. d. Megawatts: Plus or minus 2 percent.
e. Megavars: Plus or minus 2 percent.

f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1.
1. Meters: 4-inch diameter or 6 inches square, flush or semiflush, with antiparallax 250-degree scales and external zero adjustment.
2. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.

D. Instrument Switches: Rotary type with off position.
1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.

E. Feeder Ammeters: 2-1/2-inch minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.

F. Watt-Hour Meters and Wattmeters:
1. Comply with ANSI C12.1.
2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
3. Suitable for connection to three- and four-wire circuits.
4. Potential indicating lamps.
5. Adjustments for light and full load, phase balance, and power factor.
6. Four-dial clock register.
7. Integral demand indicator.
8. Contact devices to operate remote impulse-totalizing demand meter.
9. Ratchets to prevent reverse rotation.
10. Removable meter with drawout test plug.
11. Semiflush mounted case with matching cover.
12. Appropriate multiplier tag.

G. Impulse-Totalizing Demand Meter:
1. Comply with ANSI C12.1.
2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording five-minute integrated demand of totalized system.

2.5 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control Circuits: 120-V ac, supplied from remote branch circuit.

C. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

D. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

E. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.6 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

C. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.

D. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.

E. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

2.7 IDENTIFICATION

A. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.
1. Nameplate: At least 0.032-inch- thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.

B. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic (Gravoply) nameplate.
1. Nameplate: At least 0.0625-inch- thick laminated plastic (Gravoply), located at eye level on front cover of the switchboard incoming service section.

C. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.

D. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.

E. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

F. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NECA 400 and NEMA PB 2.1.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install switchboards and accessories according to NECA 400 and NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in- Place Concrete."
1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
   1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Install spare-fuse cabinet.

I. Comply with NECA 1.

3.3 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

B. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:
   1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

E. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   3. Perform the following infrared scan tests and inspections and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front and rear panels so joints and connections are accessible to portable scanner.
      b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
      c. Instruments and Equipment:
         1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Switchboard will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor- based trip, monitoring, and communication units.

END OF SECTION

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. TVSS: Transient voltage surge suppressor.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
   2. Detail enclosure types and details for types other than NEMA 250, Type 1.
   3. Detail bus configuration, current, and voltage ratings.
   4. Short-circuit current rating of panelboards and overcurrent protective devices.
   5. Include evidence of NRTL listing for series rating of installed devices.
   6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   7. Include wiring diagrams for power, signal, and control wiring.
   8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

C. Qualification Data: For qualified testing agency.

D. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field Quality-Control Reports:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

G. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member Company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on- site testing.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 1.

F. Comply with Chicago Building Code.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NECA 407.

1.8 PROJECT CONDITIONS

A. Environmental Limitations:
   1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Not exceeding minus 22 deg F to plus 104 deg F.
      b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Architect no fewer than two days in advance of proposed interruption of electric service.
   2. Do not proceed with interruption of electric service without Architect's written permission.
   3. Comply with NFPA 70E.

1.9 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

1.11 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys: Two spares for each type of panelboard cabinet lock.
   2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.
   3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Enclosures: Flush- and surface-mounted cabinets.
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Outdoor Locations: NEMA 250, Type 3R.
      c. Kitchen and Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
      d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
      e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
   2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
   3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
   4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
   5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
   6. Finishes:
      a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
      b. Back Boxes: Same finish as panels and trim.
      c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
   7. Directory Card: Inside panelboard door, mounted in transparent card holder. C.Incoming Mains Location: Top and bottom.

D. Phase, Neutral, and Ground Buses:
   1. Material: Hard-drawn copper, 98 percent conductivity.
   2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
   3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
   4. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
   5. Split Bus: Vertical buses divided into individual vertical sections.

E. Conductor Connectors: Suitable for use with conductor material and sizes.
   1. Material: Hard-drawn copper, 98 percent conductivity.
   2. Main and Neutral Lugs: Mechanical type.
   3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
   4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
   5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
   6. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

7. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

H. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include size and type of allowable upstream and branch devices, listed and labeled for series-connected short-circuit rating by an NRTL.

I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short- circuit current available at terminals.

2.2 DISTRIBUTION PANELBOARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product by one of the following:
1. Siemens Energy and Automation, Inc.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive- locking device requires mechanical release for removal.

G. Branch Overcurrent Protective Devices: Fused switches.

H. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 120-V branch circuit

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product by one of the following:
1. Siemens Energy and Automation, Inc.

C. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

D. Mains: Circuit breaker

E. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

F. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 120-V branch circuit

G. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

H. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product by one of the following:
1. Siemens Energy and Automation, Inc.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
   1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front- mounted, field-adjustable trip setting.
   3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
      a. Instantaneous trip.
      b. Long- and short-time pickup levels.
      c. Long- and short-time time adjustments.
      d. Ground-fault pickup level, time delay, and I^2t response.
   4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
   5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground- fault protection (6-mA trip).
   6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground- fault protection (30-mA trip).
   7. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
   8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
      a. Standard frame sizes, trip ratings, and number of poles.
      b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
      c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high- intensity discharge (HID) lighting circuits.
      d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
      e. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
      f. Shunt Trip: 120 V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
      g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
      h. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
      i. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
      j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
      k. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
      l. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
      m. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
      n. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
   1. Fuses, and Spare-Fuse Cabinet: Comply with requirements specified in Division 26 Section "Fuses."
   2. Fused Switch Features and Accessories: Standard ampere ratings and number of poles.
   3. Auxiliary Contacts: One normally open and normally closed contact(s) that operate with switch handle operation.

2.5 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NECA 407 and NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install panelboards and accessories according to NECA 407 and NEMA PB 1.1.

B. Equipment Mounting: Install panelboards on concrete bases, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 Section.
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
   2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to panelboards.
   5. Attach panelboard to the vertical finished or structural surface behind the panelboard.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Mount top of trim above finished floor unless otherwise indicated at a height for easy accessibility to operating handles.

F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

G. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit-breaker trip ranges. H. Install filler plates in unused spaces.

I. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

J. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

K. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

E. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   3. Perform the following infrared scan tests and inspections and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
      b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
      c. Instruments and Equipment:
         1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

F. Panelboards will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
   1. Measure as directed during period of normal system loading.
   2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
   3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
   4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Receptacles, receptacles with integral GFCI, and associated device plates.
   2. Twist-locking receptacles.
   3. Receptacles with integral surge suppression units.
   4. Wall-box motion sensors.
   5. Isolated-ground receptacles.
   6. Snap switches and wall-box dimmers.
   7. Solid-state fan speed controls.
   8. Wall-switch and exterior occupancy sensors.
   9. Communications outlets.
   10. Pendant cord-connector devices.
   11. Cord and plug sets.
   12. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

B. Related Sections include the following:
   1. Division 27 Section "Communications Horizontal Cabling" for workstation outlets.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. TVSS: Transient voltage surge suppressor.

F. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
   1. Cord and Plug Sets: Match equipment requirements.

1.7 EXTRA MATERIALS

A. Furnish extra materials described in subparagraphs below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Service/Power Poles: One for every 10, but no fewer than one.

2. Floor Service Outlet Assemblies: One for every 10, but no fewer than one.
3. Poke-Through, Fire-Rated Closure Plugs: One for every five floor service outlets installed, but no fewer than two.
4. TVSS Receptacles: One for every 10
5. of each type installed, but no fewer than two of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass and Seymour/Legrand; Wiring Devices and Accessories (Pass and Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Cooper; 5351 (single), 5352 (duplex).
b. Hubbell; HBL5351 (single), CR5352 (duplex).
c. Leviton; 5891 (single), 5352 (duplex).
d. Pass and Seymour; 5381 (single), 5352 (duplex).

2.3 GFCI RECEPTACLES

A. General Description: Straight blade, non-feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Cooper; GF20.
b. Pass and Seymour; 2084.

2.4 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Cooper; L520R.
b. Hubbell; HBL2310.
c. Leviton; 2310.
d. Pass and Seymour; L520-R.

2.5 PENDANT CORD-CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.
1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized- steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.6 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).
b. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).
c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224- 2 (four way).
d. Pass and Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).

C. Pilot Light Switches, 20 A:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Cooper; 2221PL for 120 V and 277 V.
b. Hubbell; HPL1221PL for 120 V and 277 V.
c. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V. d.Pass and Seymour; PS20AC1-PLR for 120 V.
3. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

D. Key-Operated Switches, 120/277 V, 20 A:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Cooper; 2221L.
b. Hubbell; HBL1221L.
c. Leviton; 1221-2L.
d. Pass and Seymour; PS20AC1-L.
3. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Cooper; 1995.
b. Hubbell; HBL1557.
c. Leviton; 1257.
d. Pass and Seymour; 1251.

F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory- supplied key in lieu of switch handle.
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Cooper; 1995L.
b. Hubbell; HBL1557L.
c. Leviton; 1257L.
d. Pass and Seymour; 1251L.

2.8 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

C. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
1. 600 W; dimmers shall require no derating when ganged with other devices. Illuminated when "OFF."

D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.9 OCCUPANCY SENSORS

A. Wall-Switch Sensors:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Cooper; 6111 for 120 V, 6117 for 277 V.
b. Hubbell; WS1277.
c. Leviton; ODS 10-ID.
d. Pass and Seymour; WS3000.
e. Watt Stopper (The); WS-200.
3. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft..

B. Wall-Switch Sensors:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Hubbell; AT120 for 120 V, AT277 for 277 V.
b. Leviton; ODS 15-ID.
3. Description: Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft..

C. Long-Range Wall-Switch Sensors:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Hubbell; ATP1600WRP.
b. Leviton; ODWWV-IRW.
c. Pass and Seymour; WA1001.
d. Watt Stopper (The); CX-100.
3. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, with a minimum coverage area of 1200 sq. ft..

D. Long-Range Wall-Switch Sensors:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Hubbell; ATD1600WRP.
b. Leviton; ODW12-MRW.
c. Watt Stopper (The); DT-200.
3. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft..

E. Wide-Range Wall-Switch Sensors:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Hubbell; ATP120HBRP.
b. Leviton; ODWHB-IRW.
c. Pass and Seymour; HS1001.
d. Watt Stopper (The); CX-100-3.
3. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 150-degree field of view, with a minimum coverage area of 1200 sq. ft..

F. Exterior Occupancy Sensors:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

a. Leviton; PS200-10.
b. Watt Stopper (The); EW-100-120.

3. Description: Passive-infrared type, 120/277 V, weatherproof, adjustable time delay up to 15 minutes, 180-degree field of view, and 110-foot detection range. Minimum switch rating: 1000-W incandescent, 500-VA fluorescent.

2.10 COMMUNICATIONS OUTLETS

A. Telephone Outlet:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Cooper; 3560-6.
b. Leviton; 40649.
3. Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e. Comply with UL 1863.

B. Combination TV and Telephone Outlet:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
a. Cooper; 3562.
b. Leviton; 40595.
3. Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector.

2.11 WALL PLATES

A. Single and combination types to match corresponding wiring devices.
1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.035-inch- thick, satin-finished stainless steel
3. Material for Unfinished Spaces: Galvanized steel
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant die-cast aluminum with lockable cover.

2.12 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular with satin finish.

D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.

E. Voice and Data Communication Outlet: Two modular, keyed, color-coded, RJ-45 Category 6 jacks for UTP cable.

2.13 POKE-THROUGH ASSEMBLIES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell Incorporated; Wiring Device-Kellems.
2. Pass and Seymour/Legrand; Wiring Devices and Accessories.
3. Square D/ Schneider Electric.
4. Thomas and Betts Corporation.
5. Wiremold Company (The).

C. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
1. Service Outlet Assembly: Flush type with four simplex receptacles and space for four RJ-45 jacks.
2. Size: Selected to fit nominal 3-inch cored holes in floor and matched to floor thickness.
3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
4. Closure Plug: Arranged to close unused 3-inch cored openings and reestablish fire rating of floor.

5. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of two, 4-pair, Category 5e voice and data communication cables.

2.14 MULTIOUTLET ASSEMBLIES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Hubbell Incorporated; Wiring Device-Kellems.
   2. Wiremold Company (The).

C. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

D. Raceway Material: Metal, with manufacturer's standard finish.

E. Wire: No. 12 AWG.

2.15 FINISHES

A. Color: Wiring device catalog numbers in Section Text do not designate device color.
   1. Wiring Devices Connected to Normal Power System: Ivory, unless otherwise indicated or required by NFPA 70 or device listing.
   2. Wiring Devices Connected to Emergency Power System: Red.
   3. TVSS Devices: Blue.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:
   1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
   2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
   3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
   4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:
   1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
   2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
   3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
   4. Existing Conductors:
      a. Cut back and pigtail, or replace all damaged conductors.
      b. Straighten conductors that remain and remove corrosion and foreign matter.
      c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:
   1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
   2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
   4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
   5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
   6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
   7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
   8. Tighten unused terminal screws on the device.

9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:
1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."
1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
1. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
2. Test Instruments: Use instruments that comply with UL 1436.
3. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:
1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following individually mounted, enclosed switches and circuit breakers:
   1. Fusible switches.
   2. Nonfusible switches.
   3. Molded-case circuit breakers.
   4. Molded-case switches.
   5. Enclosures.

1.3 DEFINITIONS

A. GD: General duty.

B. GFCI: Ground-fault circuit interrupter.

C. HD: Heavy duty.

D. RMS: Root mean square.

E. SPDT: Single pole, double throw.

1.4 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
   1. Enclosure types and details for types other than NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current rating.
   4. UL listing for series rating of installed devices.
   5. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Qualification Data: For testing agency.

D. Field quality-control test reports including the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Manufacturer's field service report.

F. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
   2. Time-current curves, including selectable ranges for each type of circuit breaker.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a Nationally Recognized Testing Laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in CBC, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with CBC.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.7 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Spares: For the following:
a. Potential Transformer Fuses: Three
b. Control-Power Fuses: Three
c. Fuses for Fusible Switches: Three
2. Spare Indicating Lights: Six of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 FUSIBLE AND NONFUSIBLE SWITCHES

A. Manufacturers:
1. Eaton Corporation; Cutler-Hammer Products.
2. General Electric Co.; Electrical Distribution and Control Division.
3. Siemens Energy and Automation, Inc.
4. Square D/Group Schneider.

B. Fusible Switch, 600 A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Nonfusible Switch, 600 A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

D. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.
3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

2.3 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Manufacturers:

1. Eaton Corporation; Cutler-Hammer Products.
2. General Electric Co.; Electrical Distribution and Control Division.
3. Moeller Electric Corporation.
4. Siemens Energy and Automation, Inc.
5. Square D/Group Schneider.

B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front- mounted, field-adjustable trip setting.
3. Electronic Trip-Unit Circuit Breakers: RMS sensing; field-replaceable rating plug;
with the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I^2t response.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller and let- through ratings less than NEMA FU 1, RK-5.
5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
6. GFCI Circuit Breakers: Single- and two-pole configurations with 30-mA trip sensitivity.

C. Molded-Case Circuit-Breaker Features and Accessories:
1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
4. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
5. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system
specified in Division 26 Section "Electrical Power Monitoring and Control."
6. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without with field-adjustable 0.1- to 0.6-second time delay.
8. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
9. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
10. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

D. Molded-Case Switches: Molded-case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

E. Molded-Case Switch Accessories:
1. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment.
3. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage. Provide "dummy" trip unit where required for proper operation.
4. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay. Provide "dummy" trip unit where required for proper operation.
5. Auxiliary Switch: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

6. Key Interlock Kit: Externally mounted to prohibit operation; key shall be removable only when switch is in off position.

2.4 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
   1. Outdoor Locations: NEMA 250, Type 3R.
   2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
   3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
   4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Division 26 Section "Hangers and Supports for Electrical Systems." and concrete materials and installation requirements are specified in Division 03.

3.3 INSTALLATION

A. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.

B. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.

C. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate as specified in Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect test, and adjust field-assembled components and equipment installation, including connections and to assist in field testing. Report results in writing.

B. Prepare for acceptance testing as follows:
   1. Inspect mechanical and electrical connections.
   2. Verify switch and relay type and labeling verification.
   3. Verify rating of installed fuses.
   4. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.

C. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

D. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

E. Perform the following field tests and inspections and prepare test reports:
   1. Test mounting and anchorage devices according to requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
4. Infrared Scanning:
   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors or panels so connections are accessible to portable scanner.
   b. Follow-Up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 11 months after date of Substantial Completion.
   c. Instruments, Equipment and Reports:
      1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
      2) Prepare a certified report that identifies enclosed switches and circuit breakers included and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.7 CLEANING

A. On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.

B. Inspect exposed surfaces and repair damaged finishes.

END OF SECTION

ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes ac, enclosed controllers rated 600 V and less, of the following types:
   1. Across-the-line, manual and magnetic controllers.
   2. Reduced-voltage controllers.
   3. Multispeed controllers.
   4. Variable frequency controllers for small motor applications.

B. Related Sections include the following:
   1. Division 26 Section "Electrical Power Monitoring and Control" for interfacing communication and metering requirements.
   2. Division 26 Section "Variable-Frequency Motor Controllers" for general-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on constant torque loads in ranges up to 200 hp.
   3. Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits" for low-voltage power, control, and communication surge suppressors.

1.3 SUBMITTALS

A. Product Data: For each type of enclosed controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each enclosed controller.
   1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      a. Each installed unit's type and details.
      b. Nameplate legends.
      c. Short-circuit current rating of integrated unit.
      d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.
      e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.
   2. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around enclosed controllers where pipe and ducts are prohibited. Show enclosed controller layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Qualification Data: For manufacturer and testing agency.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Routine maintenance requirements for enclosed controllers and all installed components.
   2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

G. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

H. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a Nationally Recognized Testing Laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in CBC, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with CBC.

F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed controllers, minimum clearances between enclosed controllers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Architect, Construction Manager, and Owner no fewer than seven days in advance of proposed interruption of electrical service.
   2. Indicate method of providing temporary utilities.
   3. Do not proceed with interruption of electrical service without Owner's written permission.

1.7 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03

   Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

D. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Spare Fuses: Furnish one spare for every five installed, but no fewer than one set of three of each type and rating.
   2. Indicating Lights: Two of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
2. Danfoss Inc.; Danfoss Electronic Drives Div.
3. Eaton Corporation; Cutler-Hammer Products.
4. General Electrical Company; GE Industrial Systems.
5. Rockwell Automation; Allen-Bradley Co.; Industrial Control Group.
6. Siemens/Furnas Controls.
7. Square D.

2.2 ACROSS-THE-LINE ENCLOSED CONTROLLERS

A. Manual Controller: NEMA ICS 2, general purpose, Class A, with "quick-make, quick- break" toggle or pushbutton action, and marked to show whether unit is "OFF," "ON," or "TRIPPED."
1. Overload Relay: Ambient-compensated type with inverse-time-current characteristics and NEMA ICS 2, Class 10 tripping characteristics. Relays shall have heaters and sensors in each phase, matched to nameplate, full-load current of specific motor to which they connect and shall have appropriate adjustment for duty cycle.

B. Magnetic Controller: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.
1. Control Circuit: 120 V; obtained from integral control power transformer with a control power source of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
2. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 20 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.
3. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class [10] [20] [30] tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

C. Combination Magnetic Controller: Factory-assembled combination controller and disconnect switch.
1. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by an NRTL.
2. Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.
3. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

2.3 REDUCED-VOLTAGE ENCLOSED CONTROLLERS

A. Star-Delta Controller: NEMA ICS 2, closed transition with adjustable time delay.

B. Part-Winding Controller: NEMA ICS 2, closed transition with separate overload relays for starting and running sequences.

C. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition.

D. Solid-State, Reduced-Voltage Controller: NEMA ICS 2, suitable for use with

NEMA MG 1, Design B, polyphase, medium induction motors.
1. Adjustable acceleration rate control utilizing voltage or current ramp, and adjustable starting torque control with up to 500 percent current limitation for 20 seconds.
2. Surge suppressor in solid-state power circuits providing 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
3. LED indicators showing motor and control status, including the following conditions:
a. Control power available.
b. Controller on.
c. Overload trip.

d. Loss of phase.
e. Shorted silicon-controlled rectifier.

4. Automatic voltage-reduction controls to reduce voltage when motor is running at light load.
5. Motor running contactor operating automatically when full voltage is applied to motor.

2.4 MULTISPEED ENCLOSED CONTROLLERS

A. Multispeed Enclosed Controller: Match controller to motor type, application, and number of speeds; include the following accessories:
1. Compelling relay to ensure that motor will start only at low speed.
2. Accelerating relay to ensure properly timed acceleration through speeds lower than that selected.
3. Decelerating relay to ensure automatically timed deceleration through each speed.

2.5 VARIABLE FREQUENCY CONTROLLERS

A. Description: NEMA ICS 2, pulse-width-modulated, variable frequency controller; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase, induction motor by adjusting output voltage and frequency.

B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power- transmission connection.

C. Isolation Transformer: Match transformer voltage ratings and capacity to system and motor voltages; and controller, motor, and load characteristics.

D. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

E. Unit Operating Requirements:
1. Input ac voltage tolerance of 208 V, plus or minus 5 or 380 to 500 V, plus or minus 10 percent.
2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
3. Minimum Efficiency: 96 percent at 60 Hz, full load.
4. Minimum Displacement Primary-Side Power Factor: 96 percent.
5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
6. Starting Torque: 100 percent of rated torque or as indicated.
7. Speed Regulation: Plus or minus 1 percent.
8. Ambient Temperature: 0 to 40 deg C.

F. Isolated control interface allows controller to follow control signal over an 11:1 speed range.
1. Electrical Signal: 4 to 20 mA at 24 V.
2. Pneumatic Signal: 3 to 15 psig.

G. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 2 to a minimum of 22 seconds.
4. Deceleration: 2 to minimum of 22 seconds.
5. Current Limit: 50 to a minimum of 110 percent of maximum rating.

H. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors.
2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
3. Motor Overload Relay: Adjustable and capable of NEMA 250, Class 20 performance.
4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
5. Instantaneous line-to-line and line-to-ground overcurrent trips.
6. Loss-of-phase protection.
7. Reverse-phase protection.
8. Short-circuit protection.
9. Motor overtemperature fault.

I. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

J. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Restarting during deceleration shall not damage controller, motor, or load.

K. Power-Interruption Protection: Prevents motor from re-energizing after a power interruption until motor has stopped.

L. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

M. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

N. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate controller output current, voltage, and frequency.

O. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller- off-bypass selector switch sets mode, and indicator lights give indication of mode selected.

P. Bypass Controller: NEMA ICS 2, full-voltage, nonreversing enclosed controller with across-the-line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start- stop capability in either mode.

Q. Integral Disconnecting Means: NEMA AB 1, molded-case switch with lockable handle.

R. Isolating Switch: Non-load-break switch arranged to isolate variable frequency controller and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

S. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

2.6 ENCLOSURES

A. Description: Flush- or surface-mounting cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.
1. Outdoor Locations: NEMA 250, Type 3R.
2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2.7 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Elapsed Time Meters: Heavy duty with digital readout in hours.

F. Meters: Panel type, 2-1/2-inch minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:
1. Ammeter: Output current, with current sensors rated to suit application.
2. Voltmeter: Output voltage.
3. Frequency Meter: Output frequency.

G. Multifunction Digital-Metering Monitor: Listed and labeled by an NRTL acceptable to authorities having jurisdiction, microprocessor-based unit suitable for three- or four-wire systems and with the following features:
1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
2. Switch-selectable digital display of the following:
a. Phase Currents, Each Phase: Plus or minus 1 percent.

b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent. .
d. Three-Phase Real Power: Plus or minus 2 percent.
e. Three-Phase Reactive Power: Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Integrated Demand with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
i. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

H. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.

I. Current-Sensing, Phase-Failure Relays for Bypass Controllers: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

2.8 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested enclosed controllers before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers for compliance with requirements, installation tolerances and other conditions affecting performance.
1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.

B. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

A. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."

B. Install freestanding equipment on concrete bases.

C. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Enclosed Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Fuses."

3.4 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Division 26 Section "Hangers and Supports for Electrical Systems," and concrete materials and installation requirements are specified in Division 03.

3.5 IDENTIFICATION

A. Identify enclosed controller, components, and control wiring according to Division 26 Section "Identification for Electrical Systems."

3.6 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers according to Division 26 Section "Low- Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
   1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
   2. Connect selector switches with enclosed controller circuit in both hand and automatic positions for safety-type control devices such as low- and high- pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.7 CONNECTIONS

A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
   1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
   2. Assist in field testing of equipment including pretesting and adjusting of solid- state controllers.
   3. Report results in writing.

C. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

D. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

E. Perform the following field tests and inspections and prepare test reports:
   1. Perform each electrical test and visual and mechanical inspection, Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.9 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers. Refer to Division 01 Section Demonstration and Training."

END OF SECTION

VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes solid-state, PWM, VFCs for speed control of three-phase, squirrel-cage induction motors.

B. Related Sections include the following:
   1. Division 26 Section "Electrical Power Monitoring and Control" for monitoring and control of motor circuits.
   2. Division 26 Section "Surge Protection Devices for Low-Voltage Electrical Power Circuits" for low-voltage power, control, and communication surge suppressors.

1.3 DEFINITIONS

A. BMS: Building management system.

B. IGBT: Integrated gate bipolar transistor.

C. LAN: Local area network.

D. PID: Control action, proportional plus integral plus derivative.

E. PWM: Pulse-width modulated.

F. VFC: Variable frequency controller.

1.4 SUBMITTALS

A. Product Data: For each type of VFC. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

B. Shop Drawings: For each VFC.
   1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      a. Each installed unit's type and details.
      b. Nameplate legends.
      c. Short-circuit current rating of integrated unit.
      d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.
      e. Features, characteristics, ratings, and factory settings of each motor- control center unit.
   2. Wiring Diagrams: Power, signal, and control wiring for VFCs. Provide schematic wiring diagram for each type of VFC.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs where pipe and ducts are prohibited. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Manufacturer Seismic Qualification Certification: Submit certification that VFCs, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For manufacturer and testing agency.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For VFCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Routine maintenance requirements for VFCs and all installed components.
   2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

H. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

I. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a Nationally Recognized Testing Laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain VFCs of a single type through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with City of Chicago Building Code.

F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, minimum clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver VFCs in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Store VFCs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subject to weather, cover VFCs to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:
   1. Ambient Temperature: 0 to 40 deg C.
   2. Humidity: Less than 90 percent (noncondensing).
   3. Altitude: Not exceeding 3300 feet.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.8 COORDINATION

A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

D. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Spare Fuses: Furnish one spare for every five installed, but no fewer than one set of three of each type and rating.
2. Indicating Lights: Two of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: All variable frequency controllers shall be of same manufacturer. Multiple VFC manufacturers shall not be acceptable. Subject to compliance with requirements, provide products by one of the following only:
1. Danfoss.
2. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.

2.2 VARIABLE FREQUENCY CONTROLLERS

A. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
1. Provide unit suitable for operation of standard-efficiency motor as defined by NEMA MG 1.

B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power- transmission connection.

C. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

D. Unit Operating Requirements:
1. Input ac voltage tolerance of 208 V or 480 V, plus or minus 5 percent.
2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
3. Minimum Efficiency: 96 percent at 60 Hz, full load.
4. Minimum Displacement Primary-Side Power Factor: 96 percent.
5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
6. Starting Torque: 100 percent of rated torque or as indicated.
7. Speed Regulation: Plus or minus 1 percent.

E. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
1. Electrical Signal: 4 to 20 mA at 24 V.
2. Pneumatic Signal: 3 to 15 psig (20 to 104 kPa). F. Internal Adjustability Capabilities: Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 2 to a minimum of 22 seconds.
4. Deceleration: 2 to a minimum of 22 seconds.
5. Current Limit: 50 to a minimum of 110 percent of maximum rating.

F. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors.
2. Under-and overvoltage trips; inverter over temperature, overload, and overcurrent trips.
3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 20 performance.
4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
5. Instantaneous line-to-line and line-to-ground overcurrent trips.
6. Loss-of-phase protection.

7. Reverse-phase protection.
8. Short-circuit protection.
9. Motor over temperature fault.

G. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

H. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

I. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

J. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

K. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

L. Input Line Conditioning

M. VFC Output Filtering.

N. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

O. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

P. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

Q. Control Signal Interface:
1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
2. Pneumatic Input Signal Interface: 3 to 15 psig.
3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
   a. 0 to 10-V dc.
   b. 0-20 or 4-20 mA.
   c. Potentiometer using up/down digital inputs.
   d. Fixed frequencies using digital inputs.
   e. RS485.
   f. Keypad display for local hand operation.
4. Output Signal Interface:
   a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:

1) Output frequency (Hz).
2) Output current (load).
3) DC-link voltage (VDC).
4) Motor torque (percent).
5) Motor speed (rpm).
6) Set-point frequency (Hz).

5. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   a. Motor running.
   b. Set-point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

R. Communications: Provide an MODBUS, LON works and BACNET open protocol including RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.

S. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller- off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load).

T. U.Bypass Controller: NEMA ICS 2, full-voltage, nonreversing enclosed controller with across-the-line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start- stop capability in either mode.

U. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker with lockable handle.

V. Isolating Switch: Non-load-break switch arranged to isolate VFC and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

W. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

2.3 ENCLOSURES

A. Nema type 1.

2.4 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays. E. Standard Displays:
1. Output frequency (Hz).
2. Set-point frequency (Hz).
3. Motor current (amperes).
4. DC-link voltage (VDC).
5. Motor torque (percent).
6. Motor speed (rpm).
7. Motor output voltage (V).

E. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

F. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

2.5 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested VFCs before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Select features of each VFC to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.

B. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

A. Anchor each VFC assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.

B. Install VFCs on concrete bases.

C. Comply with mounting and anchoring requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."

D. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Fuses."

3.4 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Division 26 Section "Common Work Results for Electrical," and concrete materials and installation requirements are specified in Division 03.

3.5 IDENTIFICATION

A. Identify VFCs, components, and control wiring according to Division 26 Section "Identification for Electrical Systems."

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.6 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
   1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
   2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.7 CONNECTIONS

A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
   1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
   2. Assist in field testing of equipment including pretesting and adjusting of solid- state controllers.
   3. Report results in writing.

C. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

D. Perform the following field tests and inspections and prepare test reports:
   1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.9 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain variable frequency controllers. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes transfer switches rated 600 V and less, including the following:
   1. Automatic transfer switches.
   2. Remote annunciation systems.
   3. Remote annunciation and control systems.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
   1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
      b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: For manufacturer.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Features and operating sequences, both automatic and manual.
   2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain automatic transfer switches through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NEMA ICS 1.

F. Comply with NFPA 70.

G. Comply with NFPA 99.

H. Comply with NFPA 110.

I. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.5 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:
1. Notify Owner no fewer than seven days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Contactor Transfer Switches:
a. Caterpillar; Engine Div.
b. Emerson; ASCO Power Technologies, LP.
c. Generac Power Systems, Inc.
d. GE Zenith Controls.
e. Kohler Power Systems; Generator Division.
f. Onan/Cummins Power Generation; Industrial Business Group.
g. Russelectric, Inc.
h. Spectrum Detroit Diesel.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

I. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.

J. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.

K. Battery Charger: For generator starting batteries.
1. Float type rated 10 A.
2. Ammeter to display charging current.
3. Fused ac inputs and dc outputs.

L. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

M. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification for Electrical Systems."
1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

N. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.

F. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

G. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.

H. Automatic Closed-Transition Transfer Switches: Include the following functions and characteristics:
1. Fully automatic make-before-break operation.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
a. Initiation occurs without active control of generator.
b. Controls ensure that closed-transition load transfer closure occurs only when the 2 sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
4. Failure of power source serving load initiates automatic break-before-make transfer.

I. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if

transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

J. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.

K. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.

L. Automatic Transfer-Switch Features:
1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
   a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
   b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is not available.

2.4 REMOTE ANNUNCIATOR SYSTEM

A. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:
1. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
2. Switch position.
3. Switch in test mode.

4. Failure of communication link.

B. Annunciator Panel: LED-lamp type with audible signal and silencing switch.
1. Indicating Lights: Grouped for each transfer switch monitored.
2. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
3. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
4. Lamp Test: Push-to-test or lamp-test switch on front panel.

2.5 REMOTE ANNUNCIATOR AND CONTROL SYSTEM

A. Functional Description: Include the following functions for indicated transfer switches:
1. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
2. Indication of switch position.
3. Indication of switch in test mode.
4. Indication of failure of digital communication link.
5. Key-switch or user-code access to control functions of panel.
6. Control of switch-test initiation.
7. Control of switch operation in either direction.
8. Control of time-delay bypass for transfer to normal source.

B. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically reverts to stand-alone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.

C. Remote Annunciation and Control Panel: Solid-state components. Include the following features:
1. Controls and indicating lights grouped together for each transfer switch.
2. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
3. Digital Communication Capability: Matched to that of transfer switches supervised.
4. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.

2.6 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Floor-Mounting Switch: Anchor to floor by bolting.
1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 4 inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."

C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.

D. Identify components according to Division 26 Section "Identification for Electrical Systems."

E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
   2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
   3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
      a. Check for electrical continuity of circuits and for short circuits.
      b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
      c. Verify that manual transfer warnings are properly placed.
      d. Perform manual transfer operation.
   5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
      a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
      b. Simulate loss of phase-to-ground voltage for each phase of normal source.
      c. Verify time-delay settings.
      d. Verify pickup and dropout voltages by data readout or inspection of control settings.
      e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
      f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
      g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
   6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
      a. Verify grounding connections and locations and ratings of sensors.

D. Testing Agency's Tests and Inspections:
   1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
   2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
      a. Check for electrical continuity of circuits and for short circuits.
      b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
      c. Verify that manual transfer warnings are properly placed.
      d. Perform manual transfer operation.
   4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
      a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
      b. Simulate loss of phase-to-ground voltage for each phase of normal source.
      c. Verify time-delay settings.

d. Verify pickup and dropout voltages by data readout or inspection of control settings.
e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
   a. Verify grounding connections and locations and ratings of sensors.

E. Coordinate tests with tests of generator and run them concurrently.

F. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

G. Remove and replace malfunctioning units and retest as specified above.

H. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
   1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
   2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Division 01 Section "Demonstration and Training."

B. Coordinate this training with that for generator equipment.

END OF SECTION

LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS.

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes lightning protection for buildings.

1.3 DEFINITIONS

A. LPI: Lightning Protection Institute.

B. NRTL: National recognized testing laboratory.

1.4 SUBMITTALS

A. Product Data: For air terminals and mounting accessories.

B. Shop Drawings: Detail lightning protection system, including air-terminal locations, conductor routing and connections, and bonding and grounding provisions. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.

C. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by an NRTL or LPI.

D. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply membrane roofing material.

E. Field inspection reports indicating compliance with specified requirements.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who is an NRTL or who is certified by LPI as a Master Installer/Designer.

B. Listing and Labeling: As defined in NFPA 780, "Definitions" Article.

1.6 COORDINATION

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ERICO International Corporation.
2. Harger Lightning Protection, Inc.

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Roof Mounted Air Terminals:

1. Single-Membrane, Roof-Mounting Air Terminals: Designed for single-membrane roof materials.
2. Roof-Mounting Air Terminals NFPA Class I, aluminum, solid, unless otherwise

indicated.

B. Stack-Mounting Air Terminals: Stainless steel.

C. Ground Rods, Ground Loop Conductors, and Concrete-Encased Electrodes: Comply with Division 26 Section "Grounding and Bonding for Electrical Systems" and with standards referenced in this Section.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to UL 96A and NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops.

C. Conceal the following conductors:
1. System conductors.
2. Down conductors.
3. Interior conductors.
4. Conductors within normal view from exterior locations at grade within 200 feet of building.
5. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.

D. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components, except those above single-ply membrane roofing.

E. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

F. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.

G. A counterpoise installation based on requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" may be used as a ground loop required by NFPA 780, provided counterpoise conductor meets or exceeds minimum requirements in NFPA 780.
1. Bond ground terminals to counterpoise conductor.
2. Bond grounded metal bodies on building within 12 feet of ground to counterpoise conductor.
3. Bond grounded metal bodies on building within 12 feet of roof to counterpoise conductor.

H. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot intervals.

3.2 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.3 FIELD QUALITY CONTROL

A. UL Inspection: Provide inspections as required to obtain a UL Master Label for system.

B. Provide an inspection by an inspector certified by LPI to obtain an LPI certification.

END OF SECTION

SURGE PROTECTIONS DEVICES FOR LOW VOLTAGE POWER CIRCUITS

PART 1 - GENERAL

1.1 This section describes the materials and installation requirements for Surge Protective Devices (SPDs), formerly SPD, for the protection of low voltage (120v -600v) AC electrical circuits.

1.2 STANDARDS - Most Recent Editions of:

A. Underwriters Laboratories: UL1449- 3rd Edition and UL 1283- 5th Edition

B. ANSI/IEEE C62.41.1-2002, C62.41.2-2002, C62.45-2002

C. National Electrical Code: NEC Article 285

1.3 LISTING REQUIREMENTS

A. UL 1449 Third Edition, effective 9/2009, includes extensive new performance testing. This specification centers on UL 1449 Third Edition certification to ensure comparable test evaluations and accessibility of UL's website to verify spec compliance.

B. SPD shall bear the UL Mark and shall be Listed to most recent editions of UL 1449. Type 2 SPDs shall also be co-listed to UL 1283. "Manufactured in accordance with" is not equivalent to UL listing and does not meet the intent of this specification.

C. SPD and performance parameters shall be posted at www.UL.com under Category Code: VZCA. Products or parameters without posting at UL.com shall not be approved. (To access UL Category Code VZCA click on Certifications in the left menu bar of UL's home page. Type VZCA into the Category Code search box and click Search.)

1.4 SUBMITTAL REQUIREMENTS

A. Submittals shall include UL 1449 Listing documentation verifying:
1. Short Circuit Current Rating (SCCR)
2. Voltage Protection Ratings (VPRs) for all modes
3. Maximum Continuous Operating Voltage rating (MCOV)
4. Nominal Dishcarge Current Rating ($I_{(n)}$)

B. SPD Type – All SPDs installed on the line side of the service entrance OCPD shall be Type 1 SPDs. SPDs installed on the load side of the service entrance OCPD shall be either Type 1 or Type 2 SPDs.
1. VPR, MCOV, I-n, and Type information is posted at www.UL.com, under Certifications, searching using UL Category Code: VZCA. SCCRs are posted in manufacturer's UL docs.
2. UL data and visual inspection takes precedence over manufacturer's published documentation.

C. Submittals shall include shop drawings including manufacturer installation instruction manual and line drawings detailing dimensions and weight of enclosure, internal wiring diagram illustrating all modes of protection in each type of SPD required, wiring diagram showing all field connections and manufacturer's recommended wire and breaker sizes.

D. Upon request, an un-encapsulated but complete SPD shall be presented for visual inspection; proprietary technology included. MOV type and quantity shall reflect kA ratings on cutsheets, verification of diagnostic monitoring, thermal and overcurrent protection, etc.

E. Minimum of ten (10) year warranty

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance, the following manufacturers are acceptable:
1. Advanced Protection Technologies.
2. Thomas and Betts Current Technology.
3. Square D; Schneider Electric

B. Per NEC 285.6, the short circuit current rating of the SPD shall be equal to or greater than the available short circuit current at the point on the system where installed.

C. SPD shall be UL labeled as Type 1or Type 2 SPD (verifiable at UL.com),. Every suppression component of every mode, including N-G, shall be protected by internal overcurrent and thermal over-temperature

controls. SPDs relying upon external or supplementary installed safety disconnectors do not meet the intent of this specification.

D. SPDs located at the service entrance shall be UL labeled with 20kA $I_{(n)}$(verifiable at UL.com) for compliance to UL 96A Lightning Protection Master Label and NFPA 780.

E. SPDs located at the distribution and branch panels shall be UL labeled with a minimum of 10kA $I_{(n)}$.

F. Minimum surge current capability per phase shall be:

Service Entrance or Transfer Switch:	240kA
Distribution panel boards and MCC:	160kA
Branch panel boards:	100kA

G. SPD shall provide surge current paths for all modes of protection: L-N, L-G, L-L ,and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.

H. UL 1449 Listed Voltage Protection Ratings (VPRs) shall not exceed the following:

System Voltage	L-N	L-G	L-L	N-G
208Y/120	700V	700V	1200V	700V
480Y/277	1200V	1200V	1800V	1200V

(Mode VPRs verifiable at UL.com. Numerically lower is allowed/preferred; old-style Suppressed Voltage Ratings (SVRs) shall not be submitted, nor evaluated due to outdated less-strenuous testing)

I. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

System Voltage	Allowable System Voltage Fluctuation (%)	MCOV
208Y/120	25%	150V
480Y/277	15%	320V

J. SPD shall include a serviceable, replaceable module (excluding Branch).

K. Type 2 SPDs shall have UL 1283 EMI/RFI filtering with minimum attenuation of -50dB at 100kHz.

L. SPD shall include visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED. SPD shall include an audible alarm with on/off silence function and diagnostic test function (excluding branch).

M. Additional features shall be provided as noted below.
1. SPD shall provide NO/NC dry contacts.
2. SPD shall be provided with surge event counter with back up power source.
3. SPD shall be provided with integral disconnect switch when 3-pole breaker is not available for connecting the suppressor.
4. External mounted SPD shall be within a NEMA 1 enclosure, or one that meets or exceeds the ratings for the environment to be installed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. At Service Entrance or Transfer Switch, a UL approved disconnect switch shall be provided as a means of servicing disconnect if a 60A breaker is not available.

B. At Distribution, MCC and Branch, SPD shall have an independent means of servicing disconnect such that the protected panel remains energized. A 30A breaker (or larger) may serve this function.

C. SPD shall be installed per manufacturer's installation instructions with lead lengths as short (less than 24") and straight as possible. Gently twist conductors together.

D. Installer may reasonably rearrange breaker locations to ensure short and straightest possible leads to SPDs.

E. SPD shall be installed on the load side of the main service disconnect.

F. Electrical contractor shall connect all SPD devices to building automation system with 4/C #22 AWG unshielded twisted pair cable in a ¾" conduit.

G. Before energizing, installer shall verify service and separately derived system Neutral to Ground bonding jumpers per NEC and CBC.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Interior lighting fixtures, lamps, and ballasts.
   2. Emergency lighting units.
   3. Exit signs.
   4. Lighting fixture supports.
   5. Retrofit kits for fluorescent lighting fixtures.

B. Related Sections include the following:
   1. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
   2. Division 26 Section "Network Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.
   3. Division 26 Section "Wiring Devices" for manual wall-box dimmers for incandescent lamps.

1.3 DEFINITIONS

A. BF: Ballast factor.

B. CRI: Color-rendering index.

C. CU: Coefficient of utilization.

D. HID: High-intensity discharge.

E. LER: Luminaire efficacy rating.

F. Luminaire: Complete lighting fixture, including ballast housing if provided.

G. RCR: Room cavity ratio.

1.4 SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
   1. Physical description of lighting fixture including dimensions.
   2. Emergency lighting units including battery and charger.
   3. Ballast.
   4. Energy-efficiency data.
   5. Air and Thermal Performance Data: For air-handling lighting fixtures. Furnish data required in "Submittals" Article in Division 23 Section "Diffusers, Registers, and Grilles."
   6. Sound Performance Data: For air-handling lighting fixtures. Indicate sound power level and sound transmission class in test reports certified according to standards specified in Division 23 Section "Diffusers, Registers, and Grilles."
   7. Life, output, and energy-efficiency data for lamps.
   8. Photometric data, in IESNA format, based on laboratory tests of each lighting fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
      a. For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by the manufacturer.
      b. Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.
   9. For LED lighting fixtures, submit US DOE LED Lighting Facts label, and IES L70 rated life.

B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.
   1. Wiring Diagrams: Power and control wiring.

C. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Lighting fixtures.
   2. Suspended ceiling components.
   3. Structural members to which suspension systems for lighting fixtures will be attached.
   4. Other items in finished ceiling including the following:
      a. Air outlets and inlets.
      b. Speakers.
      c. Sprinklers.
      d. Smoke and fire detectors.
      e. Occupancy sensors.
      f. Access panels.
   5. Perimeter moldings.

D. Samples for Verification: Interior lighting fixtures designated for sample submission in Interior Lighting Fixture Schedule. Each sample shall include the following:
   1. Lamps: Specified units installed.
   2. Accessories: Cords and plugs.

E. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.

F. Qualification Data: For agencies providing photometric data for lighting fixtures.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

I. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with NFPA 70.

E. FMG Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FMG.

F. Mockups: Provide interior lighting fixtures for room or module mockups, complete with power and control connections.
   1. Obtain Architect's approval of fixtures for mockups before starting installations.
   2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
   3. Approved fixtures in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.7 WARRANTY

A. Special Warranty for Ballasts: Manufacturer's standard form in which ballast manufacturer agrees to repair or replace ballasts that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Electronic Ballasts: Five years from date of Substantial Completion.
   2. Warranty Period for Electromagnetic Ballasts: Three years from date of Substantial Completion.

B. Special Warranty for T5 and T8 Fluorescent Lamps: Manufacturer's standard form, made out to Owner and signed by lamp manufacturer agreeing to replace lamps that fail in materials or workmanship, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.
   1. Warranty Period: Two year(s) from date of Substantial Completion.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
   2. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
   3. Battery and Charger Data: One for each emergency lighting unit.
   4. Ballasts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
   5. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In Interior Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
   1. Basis-of-Design Product: The design for each lighting fixture is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.

C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

D. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.

E. Metal Parts: Free of burrs and sharp corners and edges.

F. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

H. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent.
   3. Diffusing Specular Surfaces: 75 percent.
   4. Laminated Silver Metallized Film: 90 percent.

I. Plastic Diffusers, Covers, and Globes:
   1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
      a. Lens Thickness: At least 0.125 inch minimum unless different thickness is indicated.
      b. UV stabilized.
   2. Glass: Annealed crystal glass, unless otherwise indicated.

J. Electromagnetic-Interference Filters: Factory installed to suppress conducted electromagnetic-interference as required by MIL-STD-461E. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.

K. Air-Handling Fluorescent Fixtures: For use with plenum ceiling for air return and heat extraction and for attaching an air-diffuser-boot assembly specified in Division 23 Section "Diffusers, Registers, and Grilles."
   1. Air Supply Units: Slots in one or both side trims join with air-diffuser-boot assemblies.
   2. Heat Removal Units: Air path leads through lamp cavity.

3. Combination Heat Removal and Air Supply Unit: Heat is removed through lamp cavity at both ends of the fixture door with air supply same as for air supply units.
4. Dampers: Operable from outside fixture for control of return-air volume.
5. Static Fixture: Air supply slots are blanked off, and fixture appearance matches active units.

2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

A. Electronic Ballasts: Comply with ANSI C82.11; programmed-start type, unless otherwise indicated, and designed for type and quantity of lamps served. Ballasts shall be designed for full light output unless dimmer or bi-level control is indicated.
1. Sound Rating: [A] [A, except B for T12/HO and T12/Slimline lamp ballasts].
2. Total Harmonic Distortion Rating: Less than [10] [20] percent.
3. Transient Voltage Protection: IEEE C62.41, Category A or better.
4. Operating Frequency: [20] [42] <Insert value> kHz or higher.
5. Lamp Current Crest Factor: [1.7] <Insert value> or less.
6. BF: 0.85 or higher.
7. Power Factor: [0.95] [0.98] or higher.
8. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C 82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.

B. Electronic Programmed-Start Ballasts for [T5] [T5HO] [T5 and T5HO] Lamps: Comply with ANSI C82.11 and the following:
1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
2. Automatic lamp starting after lamp replacement.
3. Sound Rating: A.
4. Total Harmonic Distortion Rating: Less than 20 percent.
5. Transient Voltage Protection: IEEE C62.41, Category A or better.
6. Operating Frequency: 20 kHz or higher.
7. Lamp Current Crest Factor: 1.7 or less.
8. BF: 0.95 or higher, unless otherwise indicated.
9. Power Factor: [**0.95**] [**0.98**] or higher.

C. Electromagnetic Ballasts: Comply with ANSI C82.1; energy saving, high-power factor, Class P, and having automatic-reset thermal protection.
1. Ballast Manufacturer Certification: Indicated by label.

D. Single Ballasts for Multiple Lighting Fixtures: Factory-wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.

E. Ballasts for Low-Temperature Environments:
1. Temperatures 0 Deg F and Higher: Electronic type rated for 0 deg F starting and operating temperature with indicated lamp types.
2. Temperatures Minus 20 Deg F and Higher: Electromagnetic type designed for use with indicated lamp types.

F. Ballasts for Low Electromagnetic-Interference Environments: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for consumer equipment.

G. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.
1. Dimming Range: 100 to 10 percent of rated lamp lumens.
2. Ballast Input Watts: Can be reduced to 20 percent of normal.
3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

H. Ballasts for Bi-Level Controlled Lighting Fixtures: Electronic type.
1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
a. High-Level Operation: 100 percent of rated lamp lumens.
b. Low-Level Operation: [**30**] [**50**] percent of rated lamp lumens.
2. Ballast shall provide equal current to each lamp in each operating mode.
3. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.

2.4 BALLASTS FOR COMPACT FLUORESCENT LAMPS

A. Description: Electronic programmed rapid-start type, complying with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:
1. Lamp end-of-life detection and shutdown circuit.
2. Automatic lamp starting after lamp replacement.
3. Sound Rating: A.
4. Total Harmonic Distortion Rating: Less than 20 percent.
5. Transient Voltage Protection: IEEE C62.41, Category A or better.
6. Operating Frequency: 20 kHz or higher.
7. Lamp Current Crest Factor: 1.7 or less.
8. BF: 0.95 or higher, unless otherwise indicated.
9. Power Factor: [**0.95**] [**0.98**] or higher.
10. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
11. Ballast Case Temperature: 75 deg C, maximum.

B. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.
1. Dimming Range: 100 to 10 percent of rated lamp lumens.
2. Ballast Input Watts: Can be reduced to 20 percent of normal.
3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

2.5 BALLASTS FOR HID LAMPS

A. Electromagnetic Ballast for Metal-Halide Lamps: Comply with ANSI C82.4 and UL 1029. Include the following features, unless otherwise indicated:
1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
2. Minimum Starting Temperature: Minus 22 deg F for single-lamp ballasts.
3. Normal Ambient Operating Temperature: 104 deg F.
4. Open-circuit operation that will not reduce average life.
5. Low-Noise Ballasts: Manufacturers' standard epoxy-encapsulated models designed to minimize audible fixture noise.

B. Electronic Ballast for Metal-Halide Lamps: Include the following features unless otherwise indicated:
1. Lamp end-of-life detection and shutdown circuit.
2. Sound Rating: A.
3. Total Harmonic Distortion Rating: Less than 15 percent.
4. Transient Voltage Protection: IEEE C62.41, Category A or better.
5. Lamp Current Crest Factor: 1.5 or less.
6. Power Factor: .90 or higher.
7. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
8. Protection: Class P thermal cutout.
9. Retain subparagraph and associated subparagraphs below for bi-level ballasts.
10. Bi-Level Dimming Ballast: Ballast circuit and leads provide for remote control of the light output of the associated fixture between high- and low-level and off.
    a. High-Level Operation: 100 percent of rated lamp lumens.
    b. Low-Level Operation: [**35**] [**50**] percent of rated lamp lumens.
    c. Compatibility: Certified by ballast manufacturer for use with specific bi-level control system and lamp type indicated. Certified by lamp manufacturer that ballast operating modes are free from negative effect on lamp life and color-rendering capability.
11. Continuous Dimming Ballast: Dimming range shall be from 100 to 20 percent of rated lamp lumens without flicker.
    a. Ballast Input Watts: Reduced to a maximum of 50 percent of normal at lowest dimming setting.
    b. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated. Certified by lamp manufacturer that ballast operating modes are free from negative effect on lamp life and color-rendering capability.

C. Auxiliary Instant-On Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when power outages occur. System automatically turns quartz lamp off when HID lamp reaches approximately 60 percent light output.

D. High-Pressure Sodium Ballasts: Electromagnetic type, with solid-state igniter/starter. Igniter-starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.
   1. Instant-Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.
      a. Restrike Range: 105- to 130-V ac.
      b. Maximum Voltage: 250-V peak or 150-V ac RMS.
   2. Minimum Starting Temperature: Minus 40 deg F.
   3. Open-circuit operation shall not reduce average lamp life.

2.6 EXIT SIGNS

A. Description: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:
   1. Lamps for AC Operation: Fluorescent, 2 for each fixture, 20,000 hours of rated lamp life.
   2. Lamps for AC Operation: LEDs, 70,000 hours minimum rated lamp life.

2.7 FLUORESCENT LAMPS

A. Low-Mercury Lamps: Comply with EPA's toxicity characteristic leaching procedure test; shall yield less than 0.2 mg of mercury per liter when tested according to NEMA LL 1.

B. T8 rapid-start low-mercury lamps, rated 32 W maximum, nominal length of 48 inches, 2800 initial lumens (minimum), CRI 85 (minimum), color temperature 4100K, and average rated life 20,000 hours, unless otherwise indicated.

C. T8 rapid-start low-mercury lamps, rated 17 W maximum, nominal length of 24 inches, 1300 initial lumens (minimum), CRI 85 (minimum), color temperature 4100K, and average rated life of 20,000 hours, unless otherwise indicated.

D. T5 rapid-start low-mercury lamps, rated 28 W maximum, nominal length of 45.2 inches, 2900 initial lumens (minimum), CRI 85 (minimum), color temperature 4100K, and average rated life of 20,000 hours, unless otherwise indicated.

E. T5HO rapid-start, high-output low-mercury lamps, rated 54 W maximum, nominal length of 45.2 inches, 5000 initial lumens (minimum), CRI 85 (minimum), color temperature 4100K, and average rated life of 20,000 hours, unless otherwise indicated.

F. Compact Fluorescent Lamps: 4-Pin, low mercury, CRI 80 (minimum), color temperature 4100K, average rated life of 10,000 hours at 3 hours operation per start, and suitable for use with dimming ballasts, unless otherwise indicated.
   1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
   2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
   3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
   4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
   5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
   6. 55 W: T4, triple tube, rated 4300 initial lumens (minimum).

2.8 HID LAMPS

A. Metal-Halide Lamps: ANSI C78.1372, with a minimum CRI 65, and color temperature 4000K.

B. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000K.

C. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80, and color temperature 4000K.

2.9 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.

F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

2.10 LED LIGHT FIXTURES

A. General:
1. LED light fixtures shall be in accordance with IES, NFPA, UL, as shown on the drawings, and as specified.
2. LED light fixtures shall be Reduction of Hazardous Substances (RoHS)-compliant.
3. LED drivers shall include the following features unless otherwise indicated:
a. Minimum efficiency: 85% at full load.
b. Minimum Operating Ambient Temperature: -20˚ C. (-4˚ F.)
c. Input Voltage: 120 - 277V (±10%) at 60 Hz.
d. Integral short circuit, open circuit, and overload protection.
e. Power Factor: ≥ 0.95.
f. Total Harmonic Distortion: ≤ 20%.
g. Comply with FCC 47 CFR Part 15.
4. LED modules shall include the following features unless otherwise indicated:
a. Comply with IES LM-79 and LM-80 requirements.
b. Minimum CRI 80 and color temperature 3000˚ K unless otherwise specified in LIGHTING FIXTURE SCHEDULE.
c. Minimum Rated Life: 50,000 hours per IES L70.
d. Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.

B. LED Downlights:
1. Housing, LED driver, and LED module shall be products of the same manufacturer.

C. LED Troffers:
1. LED drivers, modules, and reflector shall be accessible, serviceable, and replaceable from below the ceiling.
2. Housing, LED driver, and LED module shall be products of the same manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.
1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches from lighting fixture corners.
2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

C. Suspended Lighting Fixture Support:
1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

D. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.

E. Adjust aimable lighting fixtures to provide required light intensities.

F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION

EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Exterior luminaires with lamps and ballasts.
   2. Luminaire-mounted photoelectric relays.
   3. Poles and accessories.
   4. Luminaire lowering devices.

B. Related Sections include the following:
   1. Division 26 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.3 DEFINITIONS

A. CRI: Color-rendering index.

B. HID: High-intensity discharge.

C. Luminaire: Complete lighting fixture, including ballast housing if provided.

D. Pole: Luminaire support structure, including tower used for large area illumination.

E. Standard: Same definition as "Pole" above.

1.4 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4.

B. Live Load: Single load of 500 lbf, distributed as stated in AASHTO LTS-4.

C. Ice Load: Load of 3 lbf/sq. ft., applied as stated in AASHTO LTS-4.

D. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.
   1. Wind speed for calculating wind load for poles exceeding 50 feet in height is 90 mph.
   2. Wind speed for calculating wind load for poles 50 feet or less in height is 90 mph.

1.5 SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
   1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
   2. Details of attaching luminaires and accessories.
   3. Details of installation and construction.
   4. Luminaire materials.
   5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.
      a. For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
      b. Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
   6. Photoelectric relays.
   7. Ballasts, including energy-efficiency data.
   8. Lamps, including life, output, and energy-efficiency data.
   9. Materials, dimensions, and finishes of poles.
   10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
   11. Anchor bolts for poles.
   12. Manufactured pole foundations.

B. Shop Drawings:
   1. Anchor-bolt templates keyed to specific poles and certified by manufacturer.

2. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
3. Wiring Diagrams: Power and control wiring.

C. Samples for Verification: For products designated for sample submission in Exterior Lighting Device Schedule. Each sample shall include lamps and ballasts.

D. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4 and that load imposed by luminaire has been included in design.

E. Qualification Data: For agencies providing photometric data for lighting fixtures.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For luminaires, poles, and luminaire lowering devices to include in emergency, operation, and maintenance manuals.

H. Warranty: Special warranty specified in this Section.

1.6 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with IEEE C2, "National Electrical Safety Code."

E. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch deep. Do not apply tools to section of pole to be installed below ground line.

D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.

E. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
1. Warranty Period for Luminaires: 3 years from date of Substantial Completion.
2. Warranty Period for Metal Corrosion: 5 years from date of Substantial Completion.
3. Warranty Period for Color Retention: 5 years from date of Substantial Completion.
4. Warranty Period for Lamps: Replace lamps and fuses that fail within 12months from date of Substantial Completion; furnish replacement lamps and fuses that fail within the second 12 months from date of Substantial Completion.
5. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
   2. Glass and Plastic Lenses, Covers, and Other Optical Parts: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
   3. Ballasts: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
   4. Globes and Guards: 10 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

B. In Exterior Lighting Device Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
   1. Basis of Design Product: The design of each item of exterior luminaire and its support is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2 LUMINAIRES, GENERAL REQUIREMENTS

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

B. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent.
   3. Diffusing Specular Surfaces: 75 percent.

K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

L. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

M. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."

2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
   a. Color: As selected from manufacturer's standard catalog of colors.
   b. Color: Match Architect's sample of custom color.
   c. Color: As selected by Architect from manufacturer's full range.

N. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
   a. Color: [Light bronze] [Medium bronze] [Dark bronze] [Black].

2.3 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.
1. Relay with locking-type receptacle shall comply with NEMA C136.10.
2. Adjustable window slide for adjusting on-off set points.

2.4 FLUORESCENT BALLASTS AND LAMPS

A. Low-Temperature Ballast Capability: Rated by its manufacturer for reliable starting and operation of indicated lamp(s) at temperatures minus 20 deg F and higher.

B. Ballast Characteristics:
1. Power Factor: 90 percent, minimum.
2. Sound Rating: A
3. Total Harmonic Distortion Rating: Less than 20 percent.
4. Electromagnetic Ballasts: Comply with ANSI C82.1, energy-saving, high power factor, Class P, automatic-reset thermal protection.
5. Case Temperature for Compact Lamp Ballasts: 65 deg C, maximum.
6. Transient-Voltage Protection: Comply with IEEE C62.41 Category A or better.

C. Low-Temperature Lamp Capability: Rated for reliable starting and operation with ballast provided at temperatures minus 20 deg F and higher.

D. Fluorescent Lamps: Low-mercury type. Comply with the EPA's toxicity characteristic leaching procedure test; shall yield less than 0.2 mg of mercury per liter when tested according to NEMA LL 1.

2.5 BALLASTS FOR HID LAMPS

A. Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction of average lamp life. Include the following features, unless otherwise indicated:
1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
2. Minimum Starting Temperature: Minus 22 deg F.
3. Normal Ambient Operating Temperature: 104 deg F.
4. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.

B. Auxiliary, Instant-On, Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when momentary power outages occur. System automatically turns quartz lamp off when HID lamp reaches approximately 60 percent of light output.

C. High-Pressure Sodium Ballasts: Electromagnetic type with solid-state igniter/starter and capable of open-circuit operation without reduction of average lamp life. Igniter/starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.

1. Instant-Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.
   a. Restrike Range: 105- to 130-V ac.
   b. Maximum Voltage: 250-V peak or 150-V ac RMS.
2. Minimum Starting Temperature: Minus 40 deg F.

2.6 HID LAMPS

A. Metal-Halide Lamps: ANSI C78.1372, with a minimum CRI 65, and color temperature 4000K.

B. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000K.

C. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80, and color temperature 4000K

2.7 LED SOURCES SHALL MEET THE FOLLOWING REQUIREMENTS:

A. Operating temperature rating shall be between -40˚ F [-40˚ C] and 120˚ F [50˚ C].

B. Correlated Color Temperature (CCT): 4000K unless otherwise specifed in the fixture schedule.

C. Color Rendering Index (CRI): ≥ 65.

D. The manufacturer shall have performed JEDEC (Joint Electron Devices Engineering Council) reliability tests on the LEDs as follows: High Temperature Operating Life (HTOL), Room Temperature Operating Life (RTOL), Low Temperature Operating Life (LTOL), Powered Temperature Cycle (PTMCL), Non-Operating Thermal Shock (TMSK), Mechanical Shock Variable Vibration Frequency, and Solder Heat Resistance (SHR).

2.8 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

A. Structural Characteristics: Comply with AASHTO LTS-4.
   1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in Part 1 "Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.
   2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
   1. Materials: Shall not cause galvanic action at contact points.
   2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless-steel items are indicated.
   3. Anchor-Bolt Template: Plywood or steel.

D. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

E. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.

F. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4.

2.9 ALUMINUM POLES

A. Poles: Seamless, extruded structural tube complying with ASTM B 429, Alloy 6063-T6 with access handhole in pole wall.

B. Poles: ASTM B 209, 5052-H34 marine sheet alloy with access handhole in pole wall.
   1. Shape: [Round, tapered] [Round, straight] [Square, tapered] [Square, straight].
   2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

D. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
   1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
   2. Finish: Same as luminaire.

F. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

G. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
   2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
   3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
   4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

2.10 DECORATIVE POLES

A. Pole Material:
   1. Cast ductile iron.
   2. Cast gray iron, according to ASTM A 48/A 48M, Class 30.
   3. Cast aluminum.
   4. Cast concrete.
   5. Spun concrete.
   6. Steel tube, covered with closed-cell polyurethane foam, with a polyethylene exterior.

B. Mounting Provisions:
   1. Bolted to concrete foundation.
   2. Embedded.

C. Fixture Brackets:
   1. Cast ductile iron.
   2. Cast gray iron.
   3. Cast aluminum.

2.11 POLE ACCESSORIES

A. Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Division 26 Section "Wiring Devices" for ground-fault circuit-interrupter type.
   1. Recessed, 12 inches above finished grade.
   2. Nonmetallic polycarbonate plastic or reinforced fiberglass cover, color to match pole, that when mounted results in NEMA 250, Type 3R or 4X enclosure.
   3. With cord opening.
   4. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.

B. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.

C. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

D. Transformer Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and accept ballasts and accessories.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources.

3.2 POLE INSTALLATION

A. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features, unless otherwise indicated on Drawings:
1. Fire Hydrants and Storm Drainage Piping: 60 inches.
2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet.
3. Trees: 15 feet.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
3. Install base covers, unless otherwise indicated.
4. Use a short piece of 1/2-inch- diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
1. Dig holes large enough to permit use of tampers in the full depth of hole.
2. Backfill in 6-inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.

F. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
1. Make holes 6 inches in diameter larger than pole diameter.
2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi at 28 days, and finish in a dome above finished grade.
3. Use a short piece of 1/2-inch- diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
4. Cure concrete a minimum of 72 hours before performing work on pole.

G. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch below top of concrete slab.

H. Raise and set poles using web fabric slings (not chain or cable).

3.3 BOLLARD LUMINAIRE INSTALLATION

A. Align units for optimum directional alignment of light distribution.

B. Install on concrete base with top above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

A. Install on concrete base with top above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 GROUNDING

A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
   1. Install grounding electrode for each pole, unless otherwise indicated.
   2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
   1. Install grounding electrode for each pole.
   2. Install grounding conductor and conductor protector.
   3. Ground metallic components of pole accessories and foundations.

3.7 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
   1. Verify operation of photoelectric controls.

C. Illumination Tests:
   1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):
      a. IESNA LM-5, "Photometric Measurements of Area and Sports Lighting."
      b. IESNA LM-50, "Photometric Measurements of Roadway Lighting Installations."
      c. IESNA LM-52, "Photometric Measurements of Roadway Sign Installations."
      d. IESNA LM-64, "Photometric Measurements of Parking Areas."
      e. IESNA LM-72, "Directional Positioning of Photometric Data."

D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain luminaire lowering devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

COMMUNICATIONS

PART 1 - GENERAL

The Contractor shall be held responsible to be familiar with the provisions contained herein and with other Sections of this Specification as applicable to the completion of the installation.

1.1 SCOPE OF WORK

A. This specification covers the furnishing and installation of materials for telecommunications system structured cabling, complete and in operating condition as indicated on drawings and/or as described herein.

1.2 QUALITY ASSURANCE

A. The following industry Standards are the basis for the structured cabling system described herein. The list is incorporated by this reference to them.
   1. ANSI/TIA/EIA 568-B.1 - General Cabling Systems Requirements.
   2. ANSI/TIA/EIA 568-B.2 - Balanced Twisted Pair Copper Cabling Systems.
   3. ANSI/TIA/EIA 568-B.3 - Optical Fiber Cabling Systems.
   4. ANSI/TIA/EIA 569B - Commercial Building Standard for Telecommunications Pathways and Spaces.
   5. ANSI/TIA/EIA 606A - The Administrative Standard for the Telecommunications Infrastructure of Commercial Buildings.
   6. ANSI-J-STD-607-A - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
   7. TIA-758-A Customer - Owned Outside Plant Telecommunications Infrastructure Standard.
   8. TIA-526-7 - Measurement of Optical Power Loss of Installed Single-mode Fiber Cable Plant.
   9. TIA-526-14-A - Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant.
   10. BICSI - Telecommunications Distribution Methods Manual (TDMM).
   11. NEC - National Electric Code.
   12. NFPA - National Fire Protection Association.
   13. IEEE - Institute of Electrical and Electronics Engineers.
   14. ISO - International Standards Organization.
   15. UL - Underwriters Laboratories.

B. These Specifications, together with the Drawings accompanying them, are intended to depict the installation requirements necessary to support this Project. Contractor shall furnish materials shown and/or called for on the Drawings but not mentioned in the Specifications, or vice versa, that are necessary for the installation and support of communications cabling, whether or not specifically called for in both. In addition, Contractor shall provide incidental equipment and materials required for the completion of systems included in this contract whether or not specified or shown on the Drawings.

C. Contractor’s management team shall have demonstrated compliance with all applicable scopes of work. Contractor must demonstrate installation requirements as a Prime Contractor or Subcontractor on no less than three (3) Higher Education projects of similar size and scope.
   1. The College may, at its discretion, require the names, previous project list, and references for the Contractor’s management team and field personnel assigned to this project prior to the start of the work.
   2. The College maintains the right to ask for replacement of management or field staff at any time during the project.

D. All cabling shall meet ANSI/TIA/EIA-568.

E. The bidder must be an authorized Belden IBDN Certified System Vendor (CSV) of the Belden IBDN System 10GX. The bidder must have successfully completed all Belden IBDN design and installation training provided by Belden Inc.

F. Termination and testing of the telecommunication cabling shall be performed by qualified telecommunication installer with at least 5 years' experience that can assure the installation and testing parameters are met.
   1. Experience with Category 6a installation is required.
   2. Vendors and Contractors shall have on staff a Building Industry Consulting Service International (BICSI) Registered Communications Distribution Designer (RCDD).
   3. The RCDD shall approve construction design and upon completion of installation, certify compliance with the standards and installation practices as specified by this document.

G. Prior to commencing the work of the project, the Contractor shall convene a meeting with the Construction Manager, College's Information Technology Services representative, and Engineering Services representative.
   1. The meeting will cover Project Specifications, Addendum, Change orders, TR layouts, labeling, and other project work, documents and site conditions.
   2. System testing procedures and requirements shall be confirmed at this time.
   3. Test report forms and schedules shall be provided for College for review.
   4. Inspection milestones will be set and notifications scheduled.
   5. Meeting minutes will be distributed and will include agreements, action items and responsible party(s) for this meeting and for future meetings when required.

H. Store materials and equipment in dry, environmentally controlled space. Do not install equipment and materials until spaces are enclosed, watertight, and dry. Protect equipment from dust and other airborne materials.

I. Contractor's regular job progress meetings with the Construction Manager and other College representatives shall include a College Information Technology Services telecommunications representative.

J. College Inspection: Earlham College will provide advising as requested.
   1. The Office of College Information Technology Services may inspect the job as it progresses.
   2. Prior to final acceptance of the work, the Contractor shall make arrangements with the appropriate authorized College personnel to inspect the construction areas, both to ensure satisfactory completion of the work and to ensure complete cleanup and restoration of areas affected by the work.
   3. Temporary protection, coverings, and structures shall be removed at or before time of inspection.
   4. Examine areas and conditions with the Installer present for compliance with requirements and other conditions affecting the performance of telecommunication transmission media.
   5. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the appropriate College personnel.

1.3 INTENT OF DRAWINGS AND SPECIFICATIONS

A. The telecommunication systems herein specified provides for Information outlets and other low voltage signaling functions (such as for energy management and security systems) through twisted pair, fiber optic, and coaxial cable.

B. The system shall provide acceptable outlets for any telecommunication device, which requires connection to other devices, networks or information services serving general College needs.

1.4 DEFINITIONS

A. OUTSIDE PLANT: Transmission facilities used in the distribution of voice, data, or video from point where it leaves one building and enters another, including copper, coax, fiber optics, and microwave.

B. ENTRANCE CABLE: The outside plant cable(s) that enter the building from the campus outside plant communication distribution network.

C. MAIN BUILDING TELECOMMUNICATION EQUIPMENT ROOM (ER): The main telecommunication room located where the outside plant cabling and backbone cabling (risers) are interconnected. This room may also serve as a floor telecommunication equipment room (TR).

D. FLOOR TELECOMMUNICATION EQUIPMENT ROOM (TR): A telecommunication equipment room normally provided on every floor of the building. Floor equipment rooms must best spaced such that the length of any horizontal cable run shall not exceed 295 feet, wire length, termination to termination.

E. BACKBONE CABLE (OSP): Cabling from outside or tunnel entrance of the Building to the Building Telecommunication Equipment Room (ER). Scope may include copper, coax, and fiber optics cabling.

F. RISER CABLE: Cabling from the Building Telecommunication Equipment Room (TR) to each Floor Telecommunication Equipment Room, including copper, coax, and fiber optics cabling.

G. STATION OUTLET BOX: The standard outlet box for telecommunications terminations shall be a double gang 4"x4"x2-1/8" minimum depth box, with mud ring sizes as required.

H. INFORMATION OUTLET: An assembly of interface ports for copper (data), fiber terminations (data), coaxial (campus television), and various audio video connections; variations of arrangements are described elsewhere in this document.

1.5 SUBMITTALS

A. Submit shop drawings and/or manufacturer's product data for telecommunications equipment, including termination equipment, copper cables, fiber optic cables, cable routing devices, and associated equipment and materials.
   1. Include cut sheets with rated capacities, operating characteristics, electrical characteristics and other measurements and descriptions which describe these items in detail.

B. Submit manufacturer's test reports and test data for each of the fiber optic cables installed.
   1. The test reports must clearly identify which fiber corresponds with the respective test measurement data so that the results can be verified prior to installation of the cable.

C. Submit a schedule of material and an installation schedule based on the construction schedule and construction phasing, to the Architect/Engineer, within three (3) weeks after contract award.

D. Submit qualifications data for material installers, supervisors, and the project RCDD (Registered Communications Distribution Designer).

E. Submit completed cable records, including floor plans, riser diagrams, manhole diagrams, footages on any cable other than horizontal cabling, and jack id's by location.

F. Submit test reports to the Owner's Representative for approval.
   1. Include in the test reports the test data taken and converted values.
   2. Prior to submittal for approval, have test reports signed by authorized witnesses present at tests.
   3. Submit two (2) final copies of approved test reports to the Owner's representative.
   4. No services shall be installed until verified reports are submitted, reviewed, and found to be acceptable by the appropriate Owners representative.

1.6 RELATED SECTIONS

A. The following sections are related:
   1. 27 05 26 - Grounding and Bonding for Communications Systems
   2. 27 05 28 - Pathways for Communications Systems
   3. 27 05 53 - Identification for Communication Systems
   4. 27 11 00 - Communications Equipment Room Fittings
   5. 27 11 16 - Communications Cabinets, Racks, Frames and Enclosures
   6. 27 11 19 - Communications Termination Blocks and Patch Panels
   7. 27 13 13 - Communications Copper Backbone Cabling
   8. 27 13 23 - Communications Optical Fiber Backbone Cabling
   9. 27 15 00.23 - Audio-Video Communications Horizontal Cabling
   10. 27 15 13 - Communications Copper Horizontal Cabling
   11. 27 15 43 - Communications Faceplates and Connectors
   12. 27 41 16 - Integrated Audio-Video Systems and Equipment
   13. 28 30 00 - Access Control System

PART 2 - PRODUCTS

2.1 PRODUCT STANDARDS

A. Products shall be as listed in this section or as directed by the Owner.

B. All products shall be new.

PART 3 - EXECUTION

3.1 TELECOMMUNICATIONS INSTALLATION

A. Installation procedures shall be in accordance with industry acceptable practices, product manufacturers' recommendations, Federal, State and Local codes and standards, and shall include demolition and removal of materials as required to support the work.

B. This section includes tools, materials, equipment and labor necessary to complete a turnkey installation, including but not limited to the following items, which will be supplied by the Contractor unless otherwise noted by the College:
   1. Cable trays, hangers, and mounting hardware
   2. Conduit
   3. Connecting blocks
   4. Cross connect cable
   5. Cross connect rings or spools
   6. Equipment racks, mounting hardware and wire management
   7. Labels for cables and receptacles
   8. Modular station receptacles
   9. Mounting brackets
   10. Painted fire retardant plywood backboards
   11. Riser cable
   12. Station blocks
   13. Station cables
   14. Velcro tie wraps, bushings, and miscellaneous

3.2 DELIVERY, STORAGE AND HANDLING

A. Deliver wire and cable properly packaged in factory-fabricated type containers, or wound on NEMA-specified type wire and cable reels.

B. Store wire and cable in clean dry space in original containers, following manufacturers' storage guidelines. Protect products from weather, damaging fumes, construction debris and traffic.

C. Handle wire and cable carefully to avoid abrading, puncturing, kinking, and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance and characteristic impedance integrity of transmission media are maintained.

3.3 SEQUENCING AND SCHEDULING

A. Coordinate with installation of wires/cables, electrical boxes and fittings, cable trays, and raceways.

B. Sequence installation of optical fiber cabling systems with other work to minimize possibility of damage during construction.

3.4 GENERAL INSTALLATION

A. No cable shall be installed in any facilities other than those intended for that use.
   1. Gas pipe and water pipes must not be used for conduit under any circumstances.

B. Install telecommunication transmission media as indicated, in accordance with manufacturers' written instructions, in compliance with applicable requirements of the NEC, and in accordance with recognized industry practices.

C. CMP (Plenum) type cable will be used for all telecommunications cables.

D. Coordinate transmission media installation work as necessary to properly interface installation of media with other work.

E. Do not install compressed, kinked, scored, deformed or abraded cable, or allow such damage to occur.
   1. Damaged materials shall be removed from the job site immediately.

F. Use extreme care in handling, fishing, and pulling-in transmission media to avoid damage to conductors, shielding and jacketing/cladding.
   1. Use pulling means including fish tape, cable, rope, and basket weave wire/cable grips, which will not damage media or raceway.
   2. If power equipment is used to pull cable, the pull speed must not exceed 30 meters per minute.
   3. Use water based lubricant approved by the cable manufacturer to ensure manufacturers pulling tensions are not exceeded.
      a. Compound used must not deteriorate conductor or insulation.
   4. Cable bending radii must not be exceeded.
   5. Pulling methods must not cause cable to twist.

6. Cables pulled through pull boxes shall be hand assisted to prevent the cable from being crushed, kinked, or scraped.
7. Provide pull strings in telecommunication conduits.
    a. To facilitate future cable installations, install a nylon pull cord in each conduit simultaneously with the pull-in of cable.
8. Pull conductors simultaneously where more than one is being installed in same raceway.
9. Splices in building media runs are NOT permitted.
    a. Building wiring must be continuous and undamaged from outlet to connecting block or connecting block to connecting block.
10. Terminations shall be made with manufacturers' stated tools and in accordance with manufacturers' instructions and guidelines.
11. Tighten connectors and terminals, including screws and bolts, in accordance with manufacturers' published torque tightening values. Where manufacturers torque requirements are not indicated, tighten connectors and terminals to comply with tightening torque specified in UL Standard.
12. When necessary within ER/TRs, horizontal station cables shall be secured with Velcro tie wraps. Both fiber and copper entrance and riser cable shall be secured with standard tie wraps. Observe the manufacturers' recommendations for distances between tie wraps and tightening tension from tie wraps and as specified in ANSI/TIA/EIA-568.
    a. Outside of ER/TRs horizontal cabling, entrance cables, and riser cables must be installed within industry standard pathways, such as cable tray, J hooks, and conduit.
13. Cables shall be permanently identified at each end with an industry approved label.
14. All wall penetrations for telecommunications cabling must be sleeved, with bushings at each end, and firestopped with removable/reusable material which has a minimum 2 hour rating, or in accordance with other architectural details, unless otherwise noted.
    a. Cables must not be installed through unsleeved holes drilled through walls.
    b. Comply with Division 07 requirements for Firestopping.
    c. Comply with TIA/EIA 569 on Firestopping.
    d. Comply with UL1479 or ASTM E814, and label with the UL1479 or ASTM E814 reference number.

3.5 TESTING AND DOCUMENTATION

A. General
1. Acceptance testing shall be completed and documentation provided to the College as soon as possible in order to permit the installation of networking equipment necessary to bring the building online for security and equipment monitoring systems.

B. Testing
1. Acceptance testing by the College shall not occur until all work in the ER/TR area is completed, including but not limited to mounting and installation of fiber OSP and riser cables, backboards, terminating boxes and cabinets, and grounding blocks, and termination of fiber riser cables, copper backbone cables, station wires, or any other work necessary for the completion of the installation.
2. The College shall have the right to schedule acceptance testing at its convenience.
3. A College representative, at the option of the College, shall be present during testing.
4. Such acceptance testing shall in no way reduce the Contractors' obligations regarding restoration, cleanup, or warranty.
5. Contractor shall perform tests necessary prior to acceptance testing to ensure that the installed cables will pass acceptance testing performed in conjunction with College representatives.
6. Contractor shall be responsible for performing, tracking, and recording the results of tests.
7. Contractor shall be responsible for providing equipment and materials necessary for as long a period of time as necessary to complete testing to the satisfaction of the College.
8. Test record forms shall be agreed to by the College prior to the commencement of acceptance testing.

C. Documentation
1. Provide record plant documentation, including jack type (information outlet), jack location, circuit length, fiber riser cable lengths, copper backbone cable lengths and any other information deemed to be useful.
2. The documentation format(s) will be agreed upon between the campus telecommunication coordinator and the Contractor.
    a. Provide all documentation in electronic format.

b. If it is agreed to use proprietary software to provide testing results, the Contractor will be required to furnish licensed system software to run it unless the College already has a licensed version of the Contractor's software.

3.6 RECORD DRAWINGS

A. Provide updated drawings of telecommunications systems in CAD format.

B. As a minimum, the data provided must include the following elements, where applicable:
   1. Inside Plant
      a. Cable Routing.
      b. Riser and OSP cable, pair (count), locations, and final cable lengths.
      c. Supporting Structures.
      d. Terminal locations and IDs.
      e. Telecommunications Room and terminal details.
      f. Conduit and cable tray routing, installation heights and section lengths.
      g. Pull box locations, installation heights and sizes.
      h. Information Outlet locations, label IDs, types, and serving ER/TR.
      i. For each change reflected on the Record Drawings, the Change Order Request number shall be shown.

3.7 WARRANTY

A. The warranty on labor and material installed by the Contractor shall be in effect for five (5) years from the date of acceptance of the work.

B. Contractor shall repair, adjust, and/or replace, whichever the College determines to be in its best interests, any defective equipment, materials, or workmanship, as well as such parts of the work damaged or destroyed by such defect, during the warranty period, at the Contractor's sole cost and expense.

C. In the event that any of the equipment specified, supplied, and/or installed as part of the work should fail to produce capacities or meet design specification as published or warranted by the manufacturer of the equipment involved or as specified in this document, the Contractor shall, in conjunction with the equipment manufacturer, remove and replace such equipment with equipment that will meet requirements without additional cost to the College.

D. In the event that the Contractor does not affect repair within seven (7) days from the date of notification of such defect, the College may secure repair services from other sources and charge the Contractor for such costs without voiding the warranty.

E. Guarantees of material, equipment, and workmanship running in favor of the Contractor shall be transferred and assigned to the College on completion of the work and acceptance of said work by the College.

END OF SECTION

GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, and labeling of grounding and bonding infrastructure and includes the following:
   1. Grounding Busbars
   2. Bonding Connections

B. Related Sections include the following:
   1. 27 05 53 - Identification for Communications Systems
   2. 27 11 00 - Communications Equipment Room Fittings
   3. 27 11 16 - Communications Cabinets, Racks, Frames and Enclosures
   4. 27 11 19 - Communications Termination Blocks and Patch Panels
   5. 27 15 43 - Communications Faceplates and Connectors

1.2 QUALITY ASSURANCE

A. All equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the approval of the Owner. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based on the acceptable manufacturers listed. Where "Or equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

1.3 SUBMITTALS

A. Provide the following for all products (submit with bid):
   1. Manufacturers' cut sheets
   2. Specifications
   3. Installation instructions

1.4 DEFINITIONS

A. Bonding - Refers to the electrical interconnection of conductive parts designed to maintain a common electrical potential. Bonding conductors must be of sufficient gauge to carry anticipated current due to power contact.

B. Bonding Conductor (BC) - Typical bonding conductor installed from any telecommunications grounding bus bar (TMGB or TGB) to telecommunications equipment and/or raceway.

C. Electromagnetic Interference (EMI) - The interference in signal transmission or reception resulting from the radiation of electrical or magnetic fields.

D. Grounding - Refers to the electrical connection of telecommunications hardware to an effective electrical ground. An effective electrical ground can be a power system Multi-Grounded Neutral (MGN), a grounded neutral of a secondary power system, or a specially constructed grounding system.

E. Multi-Grounded Neutral (MGN) - A utility power system where the neutral conductor is continuously present along with the phase conductors. The neutral conductor is connected to earth periodically along its path.

F. Telecommunications Bonding Conductor (TBC) - The bonding conductor installed from the building’s grounding electrode system to the TMGB. This bonding conductor shall be sized the same as the TBB.

G. Telecommunications Bonding Backbone (TBB) - Continuous bonding conductor installed from the TMGB to the furthest telecommunications room. All TGB's shall attach to the TBB.

H. Telecommunications Main Grounding Busbar (TMGB) - The main telecommunications grounding bar located where the Outside Plant cables enter the telecommunications room.

I. Telecommunications Grounding Busbar (TGB) - The telecommunications grounding bar located in every telecommunications room that does not contain the TMGB.

PART 2 - PRODUCTS

2.1 WALL MOUNTED BUSBARS

A. Telecommunications Main Grounding Busbar (TMGB)
1. TMGB shall be constructed of 1/4" (6.4 mm) thick solid copper bar.
2. The busbar shall be 4" (101.6 mm) high and 12" (304.8 mm) long and shall have 18 attachment points (two rows of 9 each) for two-hole grounding lugs.
3. The hole pattern for attaching grounding lugs shall meet the requirements of ANSI-J-STD – 607-A and shall accept 15 lugs with 5/8" (15.9 mm) hole centers and 3 lugs with 1" (25.4 mm) hole centers.
4. The busbar shall include wall-mount stand-off brackets, assembly screws and insulators creating a 4" (101.6 mm) standoff from the wall.
5. The busbar shall be UL Listed as grounding and bonding equipment.
6. Acceptable manufacturers:
   a. Chatsworth Products, Inc. (CPI)
   b. Or equal

B. Telecommunications Grounding Busbar (TGB)
1. TGB shall be constructed of 1/4" (6.4 mm) thick solid copper bar.
2. The busbar shall be 2” (50.8 mm) high and 12” (304.8 mm) long and shall have 9 attachment points (one row) for two-hole grounding lugs.
3. The hole pattern for attaching grounding lugs shall meet the requirements of ANSI-J-STD – 607-A and shall accept 6 lugs with 5/8” (15.9 mm) hole centers and 3 lugs with 1” (25.4 mm) hole centers.
4. The busbar shall include wall-mount stand-off brackets, assembly screws and insulators creating a 4" (101.6 mm) standoff from the wall.
5. The busbar shall be UL Listed as grounding and bonding equipment.
6. Acceptable Manufacturers:
   a. Chatsworth Products, Inc. (CPI)
   b. Or equal

2.2 RACK MOUNT BUSBAR

A. Vertical Rack Busbar
1. Vertical rack-mount busbar shall be constructed of 1/4" (6.4 mm) thick by 5/8" (15.9 mm) high hard-drawn electrolytic tough pitch 110 alloy copper bar.
2. Bar shall be 36" Long for mounting on relay racks or in cabinets.
3. Bar shall have eight 6-32 tapped ground mounting holes on 1" (25.4 mm) intervals and four 0.281" (7.1 mm) holes for the attachment of two-hole grounding lugs.
4. Each bar shall include a copper splice bar of the same material (to transition between adjoining racks) and two each 12-24 x 3/4" copper- plated steel screws and flat washers for attachment to the rack or cabinet.
5. Bar shall be UL Listed as grounding and bonding equipment.
6. Acceptable Manufacturers:
   a. Chatsworth Products, Inc. (CPI)
   b. Or equal

2.3 BONDING ACCESSORIES

A. Two Mounting Hole Ground Terminal Block
1. Ground terminal block shall be made of electroplated tin aluminum extrusion.
2. Ground terminal block shall accept conductors ranging from #14 AWG through 2/0.
3. The conductors shall be held in place by two stainless steel set screws.
4. Ground terminal block shall have two 1/4" (6.4 mm) holes spaced on 5/8" (15.9 mm) centers to allow secure two-bolt attachment to the rack or cabinet.
5. Ground terminal block shall be UL Listed as a wire connector.
6. Acceptable Manufacturers:
   a. Chatsworth Products, Inc. (CPI)
   b. Or equal

B. Compression Lugs
1. Compression lugs shall be manufactured from electroplated tinned copper.

2. Compression lugs shall have two holes spaced on 5/8" (15.8 mm) or 1" (25.4 mm) centers, as stated below, to allow secure two bolt connections to busbars.
3. Compression lugs shall be sized to fit a specific size conductor, sizes #6 to 4/0.
4. Compression lugs shall be UL Listed as wire connectors.
5. Acceptable Manufacturers:
   a. Chatsworth Products, Inc. (CPI)
   b. Or equal

C. Antioxidant Joint Compound
1. Oxide inhibiting joint compound for copper-to-copper, aluminum-to- aluminum or aluminum-to-copper connections.

D. C-Type Compression Taps
1. Compression taps shall be manufactured from copper alloy.
2. Compression taps shall be C-shaped connectors that wrap around two conductors forming an irreversible splice around the conductors; installation requires a hydraulic crimping tool.
3. Compression taps shall be sized to fit specific size conductors, sizes #2 AWG to 4/0.
4. Compression taps shall be UL Listed.
5. Acceptable Manufacturers:
   a. Chatsworth Products, Inc. (CPI)
   b. Or equal

E. Pipe Clamp With Grounding Connector
1. Pipe clamp shall be made from electroplated tinned bronze. Installation hardware will be stainless steel.
2. Pipe clamp shall be sized to fit up to two conductors ranging in size from #6 to 250 MCM; conductors must be the same size.
3. Pipe clamp installation hardware shall be sized to attach to pipes, sizes 1" to 6" (3/4" to 6.63" in diameter), as stated below.
4. Pipe clamp shall be UL Listed as grounding and bonding equipment.
5. Acceptable Manufacturers:
   a. Chatsworth Products, Inc. (CPI)
   b. Or equal

F. Equipment Ground Jumper Kit
1. Kit includes one 24” long insulated ground jumper with a straight two hole compression lug on one end and an L-shaped two hole compression lug on the other end, two plated installation screws, an abrasive pad and a 1/2 ounce tube of antioxidant joint compound.
2. Ground conductor is an insulated green/yellow stripe #6 AWG wire.
3. Lugs are made from electroplated tinned copper and have two mounting holes spaced 1/2" to 5/8" apart that accept 1/4" screws.
4. Jumper will be made with UL Listed components.
5. Acceptable Manufacturers:
   a. Chatsworth Products, Inc. (CPI)
   b. Or equal

PART 3 - EXECUTION

3.1 GENERAL

A. Bond metallic equipment racks, conduits, cable tray, and ladder racks to the ground bar.

B. All connectors and clamps shall be mechanical type made of silicon bronze.

C. Terminals shall be solderless compression type, copper long-barrel NEMA two bolt.

D. Bond the shield of shielded cable to the ground bar in telecommunications rooms and spaces.

E. Provide #6 AWG grounding conductor from the busbar to the electrical system equipment ground.

F. Grounding wire shall be appropriately bonded to the TMGB or TGB.

3.2 INSTALLATION

A. Wall Mount Busbars
   1. Locate grounding bus bars to minimize ground wire lengths; location shall be coordinated with the College Information Technology Services representative and Project electrical engineer.
   2. Attach busbars to the wall with appropriate hardware according to the manufacturer's installation instructions.
   3. Conductor connections to the TMGB or TGB shall be made with two-hole bolt-on compression lugs sized to fit the busbar and the conductors.
   4. Each lug shall be attached with stainless steel hardware after preparing the bond according to manufacturer recommendations and treating the bonding surface on the busbar with antioxidant to help prevent corrosion at the bond.
   5. The wall mounted busbar shall be bonded to the ground as part of the overall Telecommunications Bonding and Grounding System.
   6. The busbars shall be bonded to any electrical panelboards that occupy the same room using a minimum #6 AWG copper conductor with a maximum length of 13 feet.
   7. All ungrounded telecommunications racks and metallic raceways in the same room as the TMGB shall be bonded to the TMGB.
   8. The TMGB shall be bonded the building ground system ground or building structural steel.
   9. Provide a solid or stranded copper wire building earth ground bonded to the electric power ground from the Grounding busbar in the ER. All ground wires shall be continuous and un-spliced between ER and TR grounding busbars.
   10. The TMGB shall be grounded to the TGB in each TR, forming the Telecommunications Bonding Backbone (TBB) with copper ground wire solid or stranded, insulated or uninsulated, according to length, as detailed in J-STD-607, shown below:

WIRE LENGTH	WIRE SIZE (AWG)
< 4 m / < 13 ft	6
4-6 m / < 14-20 ft	4
6-8 m / < 21-26 ft	3
8-10 m / < 27-33 ft	2
10-13m / < 34-41 ft	1
13-16m / < 42-52 ft	1/0
16-20m / < 53-66 ft	2/0
> 20 m / > 66 ft	3/0

   11. The TMGB shall be bonded to the Alternating Current Electrical Ground (ACEG) with a copper ground wire of not smaller gauge than that used for the TBB.

B. Rack Mount Busbars and Ground Bars
   1. When a rack or cabinet supports active equipment or any type of shielded cable or cable termination device requiring a ground connection, add a rack mount horizontal or vertical busbar or ground bar to the rack or cabinet. The rack mount busbar or ground bar provides multiple bonding points on the rack for rack and rack mount equipment.
   2. Attach rack mount busbars and ground bars to racks or cabinets according to the manufacturer's installation instructions.
   3. Bond the rack mount busbar or ground bar to the room's TMGB or TGB with appropriately sized hardware and conductor.

C. Ground Terminal Block
   1. Every rack and cabinet shall be bonded to the TGB.
   2. Minimum bonding connection to racks and cabinets shall be made with a rack mount two-hole ground terminal block sized to fit the conductor and rack and installed according to manufacturer recommendations.
   3. Remove paint between rack/cabinet and terminal block, clean surface and use antioxidant between the rack and the terminal block to help prevent corrosion at the bond.

D. Pipe Clamp
   1. Bond metal pipes located inside the ER or TR with a minimum #6 AWG conductor to the TMGB or TGB using a pipe clamp sized to fit the pipe and the conductor and installed according to the manufacturer's recommendations.

2. Remove paint between the pipe and pipe clamp, clean surface and use antioxidant between the pipe and the clamp to help prevent corrosion at the bond.
3. Remove insulation from conductors where wires attach to the pipe clamp.

E. Equipment Ground Jumper Kit
1. Bond equipment to the horizontal rack mount busbar or ground bar using a ground jumper according to the manufacturer's recommendations.
2. Clean the surface and use antioxidant between the compression lugs on the jumper and the rack mount busbar or ground bar to help prevent corrosion at the bond.

3.3 INSTALLATION OF BONDING CONDUCTORS

A. Shall be routed so as to minimize bends and length.

B. Shall be a minimum of #6 AWG.

C. Bonding Conductors shall maintain a horizontal or downward path to the TMGB or TGB. No bend shall form an included angle of more than 90 degrees or have a radius of less than 6".

D. Use appropriate HTAP kit to bond the TBB to the TMGB or TGB.

END OF SECTION

PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes minimum requirements for the following:
   1. Interior Horizontal Cabling Communication Pathways.

B. Minimum requirements and installation methods for the following pathways:
   1. Conduit
   2. Corridor Cable Tray
   3. Cable Hangers
   4. Wireways and Wore Troughs

C. Related work specified elsewhere:
   1. 27 15 13 - Copper Horizontal Cabling
   2. Division 28 - Electronic Safety and Security
   3. Division 26 - Electrical

1.2 QUALITY ASSURANCE

A. All pathways and associated equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the architect and Owners Project Manager. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Materials and work specified herein shall comply with the applicable requirements of:
   1. National Electric Code (NFPA 70) including the following Articles:
      a. 318 Cable Trays
      b. 331 Electrical Nonmetallic tubing
      c. 348 Electrical metallic tubing
      d. 349 Flexible metallic tubing
      e. 350 Flexible metal conduit
      f. 351 Liquid-Tight Flexible metal conduit and Liquid-Tight flexible nonmetallic conduit
      g. 352A Surface Metal Raceways
      h. 352B Surface Nonmetallic raceways
      i. 353 Multioutlet Assembly
      j. 354 Underfloor raceways
      k. 362 Metal Wireways and nonmetallic Wireways
      l. 370 Outlet, Device, Pull and Junction Boxes, Conduit Bodies and Fittings
      m. 645 Information Technology Equipment
      n. 770 Optical Fiber Cables and Raceways
      o. 800 Communications Circuits
   2. The following American National Standards Institute (ANSI) standards:
      a. ANSI-C80.3 Specification for Electrical Metallic Tubing, Zinc-coated
   3. The following Telecommunication Industry Association (TIA) standards:
      a. ANSI/TIA/EIA – 568-B Commercial Building Telecommunications Cabling Standard
      b. ANSI/TIA/EIA – 569-A Commercial Building Standard for Telecommunications Pathway and Spaces
      c. EIA/TIA-606-A Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
      d. EIA/TIA-607 Commercial Building Grounding and Bonding requirements for Telecommunications
   4. The following BICSI guidelines:
      a. BICSI Telecommunications Distribution Design Manual (Most Recent Edition)
      b. BICSI Telecommunications Cabling Installation Manual (Most Recent Edition)
   5. The following UL standards:
      a. UL 1, 2000 Flexible Metal Electrical Conduit
      b. UL 3, 1999 Flexible Nonmetallic Tubing for Electric Wiring
      c. UL 5, 1996 Surface Metal Electrical Raceways and Fittings
      d. UL 360, 1996 Liquid-Tight Flexible Steel Conduit, Electrical
      e. UL 514B, 1996 Fittings for Conduit and Outlet Boxes

f. UL 797, 1997 Electrical Metallic Tubing
g. UL 870, 1995 Electrical Wireways, Auxiliary Gutters and Associated Fittings

1.3 SUBMITTALS

A. Contractors shall provide product data for the all the equipment specified herein.

PART 2 - PRODUCTS

2.1 CONDUIT

A. All telecommunications conduit and boxes are provided for under Division 26.

2.2 CABLE HANGERS

A. Provide prefabricated, zinc coated, carbon steel wide base hangers designed specifically for data communications and audio visual cable installations.

B. Hanger and supports must be NRTL (Nationally Recognized Testing Laboratories) labeled for support of Category 6e cabling.

C. Hangers shall have open top, rolled edges and a 2” to 4” minimum diameter loop as required.

D. Provide beam clamps, rod fasteners, flange clips and brackets as job conditions require.

E. Acceptable Manufacturers:
1. Panduit J-Pro series
2. Panduit J-Mod series
3. Erico Caddy CAT J-Hook: Cat32
4. Erico Caddy CableCat Wide Base Cable Support Clips

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. The intention of the telecommunications conduits is to provide a route between ER and TR rooms, routes from the TR’s throughout building floors to hallways, hand routes from hallway distribution systems into rooms to individual drop locations for telecommunications cabling.

B. Installation of new pathways shall not interfere with existing pathways in such a way that installation of new cables within the existing pathway is made more difficult.

C. Support raceways from building construction. Do not support raceways from ductwork piping, or equipment hangers.

D. Support outlet, pull, and junction boxes independently from building construction. Do not support from raceways.

E. Coordinate all raceway runs with other trades.

F. All open raceways shall be installed away from any light fixture or other source of EMI (Electro-magnetic interference).
1. Open cables and cables in nonmetallic raceways and unshielded power:
   a. Electrical less than 2 kVa - 5 inch minimum
   b. Electrical 2 to 5 kVa - 12 inch minimum
   c. Electrical greater than 5 kVa - 24 inch minimum
2. Cables in grounded metallic raceways and unshielded power:
   a. Electrical less than 2 kVa - 2-1/2 inch minimum
   b. Electrical 2 to 5 kVa - 6 inch minimum
   c. Electrical greater than 5 kVa - 12 inch minimum
3. Cables in grounded metallic raceways and shielded power:
   a. Electrical less than 2 kVa - 1 inch minimum
   b. Electrical 2 to 5 kVa - 3 inch minimum
   c. Electrical greater than 5 kVa - 6 inch minimum
4. Cables and electrical motors and transformers 5 kVa or larger - 48 inches
5. Cables and fluorescent fixtures - 5 inches

G. All horizontal pathways shall be bonded and grounded per the NEC Article 250.

H. In all cases, horizontal pathways shall be sized for a minimum of 60% future growth.

I. Horizontal distribution cables shall be bundled in groups of no more than 50 cables. Cable bundle quantities in excess of 50 cables may cause deformation of the bottom cables within the bundle and degrade cable performance.

3.2 CORRIDOR CABLE TRAY SYSTEM

A. Complete wall mounted or suspended cable basket system and necessary accessories shall be provided as shown on plans. Install entire cable basket system in accordance with manufacturer's minimum installation practices and all local governing codes.

B. Coordinate installation of cable tray with other trades to allow a minimum of 12" above, 6" in front, and 3" below of clearance from piping, conduits, ductwork, etc.

C. Submittal drawings, in the form of 8 ½"x 11" catalog cut sheets, shall be provided for the following items: cable tray, fittings, accessories and load data.

D. Cable tray shall not be loaded beyond 60% of manufacturer's recommended load capacity.

E. Where a new cable basket distribution system encounters a wall, install sufficient 4" EMT sleeves or EZ Path fire stopping sleeves through the wall so cabling does not exceed 20% fill.

F. Where cable basket is exposed below ceiling, install the appropriate solid bottom inserts to conceal cables.

G. Install cable basket dropouts where large quantities of cables exit the distribution system.

H. Manufacturer of basket cable tray in corridors shall be WBT, Cablofil, B-Line Systems Flex Tray, or approved equal.

I. Provide factory manufactured tee fittings and 90 degree fittings to maintain the tray performance characteristics. Utilize factory splice connectors to maintain the tray ground integrity.

3.3 CONDUIT AND BACKBOXES

A. All telecommunications conduit and boxes are provided for under Division 26.

3.4 CONDUIT SLEEVES

A. Install a 4" Conduit Waterfall on all 4" conduit sleeves containing cables that transition more than 6" vertically from the sleeve down to another raceway (conduit or cable tray).

B. Install Nylon Cable Protectors in conduits where large amounts of cables enter/exit the conduit system creating pressure on the cables on the leading conduit edge. These protectors would not be used on 4" conduits where the Panduit Waterfall is required (more than 6" of vertical drop).

C. Install EZ Path sleeves where cables must penetrate fire-rated walls between sections of skeletal conduit or cable tray sections.

3.5 CABLE HANGERS

A. J-hooks shall be installed per ANSI/EIA/TIA 569 Commercial Building Standards for Telecommunications Pathways and Spaces.

B. Provide cable hangers a maximum of 3' on center wherever cable tray or conduit is not present.

C. Load hangers as recommended by the manufacturer. Provide hangers side by side on a common bracket where cable quantities require.

D. Do not install cables loose above lock-in type, drywall or plaster ceilings.

E. Cables shall be installed at least six (6) inches above the ceiling tiles and shall not touch the ceiling.

F. Do not support cable from ceiling system tie wires or grid in fire rated systems.

3.6 SUPPORTING DEVICES

A. Provide steel angles, channels and other materials necessary for the proper support of wall-mounted cabinets, racks, panels, etc.

B. Cabinets, large pull boxes, and cable support boxes shall be secured to ceiling and floor slab and not supported from conduits. Small equipment boxes, etc., as approved by the Architect and Project Manager, may be supported on walls.

C. Racks for support of conduit and heavy equipment shall be secured to building construction by substantial structural supports.

3.7 FIRE STOPS

A. In all buildings, floor/ceiling assemblies, stairs, and elevator penetrations must be sealed with a 2-hour fire stop assembly at a minimum, unless otherwise noted.

B. Contact Architect to identify walls which are fire-rated construction. Walls must be sealed with a 2-hour fire stop assembly at a minimum.

C. Communication pathways requiring fire stopping shall utilize removable/re-usable fire stopping putties for ease of Moves, Adds, and Changes.

D. All fire stopping penetrations shall conform to the recommended practices listed in UL1479 or ASTM E814 and must be labeled with the UL1479 or ASTM E814 reference number, dated, and signed by the technician who installed the fire stopping material.

END OF SECTION

IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes the minimum requirements for the installation, termination, and labeling of all faceplates and connectors as depicted on the Technology Drawings and required by these specifications.

B. Related Sections include the following:
   1. 27 05 26 - Grounding and Bonding for Communications Systems
   2. 27 11 16 - Communications Cabinets, Racks, Frames and Enclosures
   3. 27 11 19 - Communications Termination Blocks and Patch Panels
   4. 27 15 13 - Communications Copper Horizontal Cabling
   5. 27 15 43 - Communications Faceplates and Connectors

PART 2 - PRODUCTS

2.1 LABELS

A. Products shall provide labeling options that comply with the TIA/EIA-606-A Standard. All products shall be clearly identified. Products shall include faceplates, surface mount boxes, patch panels, marker ties, printers and accessories.

B. Shall meet the legibility, defacement, exposure and adhesion requirements of UL 969.

C. Shall be preprinted or laser printed type.

D. Where used for cable marking provide vinyl substrate with a white printing area and a clear “tail” that self laminates the printed area when wrapped around the cable.

E. Where insert type labels are used, provide clear plastic cover over label.

F. A standard style, size 10, bold font type shall be used when making faceplate labels. All label heights shall be the same to allow for consistent labeling. A Cable Management Inventory Record shall be used to record all installation details.

G. Acceptable Manufacturers:
   1. Brady LAT-176-124(2) 0.375x1.90 (No Exceptions)

PART 3 - EXECUTION

3.1 IDENTIFICATION AND LABELING

A. The telecommunications Contractor’s onsite representative(s) shall schedule a meeting with the College Information Technology representative through the appropriate Project Manager prior to the permanent labeling of Information Outlets and TR patch panels.

B. Label all horizontal cabling specifically corresponding to where the cable terminates in the ER/TR. Label both ends of each horizontal cable as shown on the drawings. Numbers shall be sequential and Contractor shall confirm labeling with Owner prior to installation.

C. Faceplates and Patch Panels:
   1. Label faceplates at the Information Outlets specifically corresponding to the horizontal cable labeling scheme.
   2. Labels shall be mounted in a manner which permits easy access and viewing.

D. Information Outlet receptacles, cables, and terminations shall be labeled with a standard identification tag at both the Information Outlet and on the patch panels/wiring blocks in the ER/TR.

E. Tags shall be preprinted or computer printed with indelible water proof ink and mechanically secured in a permanent fashion; for example, such as using an appropriate label maker with 3/8” tape.

F. Handwritten labels are NOT acceptable.

G. Labeling scheme:
   1. The station cable serving each receptacle must be labeled at the room receptacle and the TR rack.

2. Information Outlet receptacles in rooms are to be labeled -A through -ZZ in each room beginning with the first receptacle to the left of the main entrance to the room and continuing clockwise around the room.
3. All labeling will be done in all capital letters.
4. For example, a jack labeled 246A-A would be labeled such because:
   a. Room 246A is the room number
   b. The Information Outlet designation is “A” (first receptacle in room from the left of the door)
   c. Station cables from a given room shall be terminated in sequential order, i.e. – 246A-A, 246A-B, 246A-C, 246A-D, etc. If more than 26 are needed, the progression would be – 246A-X, 246A-Y, 246A-Z, 246A-AA, 246A-AB, 246A-AC, … 246A-AZ, 246A-BA, 246A-BB, etc.

H. Information Outlets for special purposes shall have a unique identifier listed with the jack ID.

I. The identifier shall be inserted into the Outlet ID, between the room number and the Outlet designator as indicated in the drawings.

J. Common identifiers are listed below:
1. Wireless access point (WAP) "100+WD-A"
2. Elevator jack "100+EL-A"
3. Card Reader "100+CR-A"
4. Fire Alarm "100+FA-A"
5. Security Camera “100+SC-A”

K. All labeling shall be coordinated with and approved by an appropriate College representative.
1. Schedule a meeting with the College Information Technology representative through the Project Manager prior to the permanent labeling of Information Outlets and ER/TR patch panels.

L. Contractor shall label all Audio Visual signal cabling at both the source and destination and be placed on both the cable jacket and the connector termination.

3.2 RECORD COPY AND AS - BUILT DRAWINGS

A. Provide record copy drawings (in CAD format) periodically throughout the project as requested by the Project Manager and also at end of the project. Record copy drawings shall include notations reflecting the as-built conditions of any additions to or variation from the drawings provided.

B. Provide hard copy and electronic copy of cable inventory which includes all circuit numbers for UTP cabling.

END OF SECTION

COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Work covered by this Section shall consist of furnishing labor, equipment, supplies, and materials unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, and labeling of all telecommunications infrastructure as described on the Drawings and/or required by these specifications.

1.2 RELATED SECTIONS

A. Related sections include the following:
   1. 27 05 26 - Grounding and Bonding for Communications Systems
   2. 27 05 53 - Identification for Communication Systems
   3. 27 11 16 - Communications Cabinets, Racks, Frames and Enclosures
   4. 27 11 19 - Communications Termination Blocks and Patch Panels
   5. 27 15 13 - Communications Copper Horizontal Cabling
   6. 27 15 43 - Communications Faceplates and Connectors

1.3 INTENT OF DRAWINGS AND SPECIFICATIONS

A. These Specifications, together with the Drawings accompanying them, are intended to depict the installation requirements necessary to support this Project. Contractor shall furnish materials shown and/or called for on the Drawings but not mentioned in the Specifications, or vice versa, that are necessary for the installation and support of communications cabling, whether or not specifically called for in both. In addition, Contractor shall provide incidental equipment and materials required for the completion of systems included in this Contract whether or not specified or shown on the Drawings.

PART 2 - PRODUCTS

2.1 PRODUCT STANDARDS

A. All materials shall conform with the current applicable industry standards including, but not limited to:
   1. NEMA (National Electrical Manufacturers' Association)
   2. ANSI (American National Standards Institute)
   3. ASTM (American Society for Testing and Materials)
   4. ICEA (Insulated Cable Engineers Association)
   5. National Electrical Safety Code

B. In addition, all Material shall be Underwriters Laboratories Listed unless otherwise indicated.

C. All products must be new.

2.2 TELECOMMUNICATIONS ROOM PLYWOOD

A. 3/4" fire retardant plywood, grade B-C.

2.3 TELECOMMUNICATIONS ROOM CABLE TRAY

A. Chatsworth 10250-712 tubular runway.

B. Shall include Runway elevation kit if needed.

C. Include all splice kits, ground straps, and support kits as required.

D. Provide all other associated parts as needed.

PART 3 - EXECUTION

3.1 EQUIPMENT ROOM FITTINGS

A. New ER/TRs must be free from dust, dirt, and other foreign materials before the installation of any termination hardware or the termination of copper or fiber optic cables. The door to the telecommunication rooms must be permanently installed and closed during termination.

B. Each Contractor shall be knowledgeable of work to be performed by other trades and take necessary steps to integrate and coordinate their work with other trades.

C. The Contractor shall be responsible for furnishing all materials on the drawings or as specified herein for a complete telecommunications system.

D. All telecommunications infrastructure shall be installed utilizing BICSI installation practices in an aesthetically pleasing and organized fashion. All surface raceway in new buildings must be approved by the College Information Technology Services Representative.

E. All telecommunications infrastructure shall be installed for optimal performance.

F. All telecommunications infrastructure shall be installed to accommodate future moves, adds, and changes.

G. All work performed in occupied spaces shall be in a manner that allows the owner to operate the existing facilities on a continuous basis.

3.2 BACKBOARDS

A. Install 3/4" fire-retardant plywood horizontally on all walls from 2' 0" to 6' 0" AFF.
   1. Backboards shall be painted with two (2) coats of fire retardant paint on all sides, or fire-retardant treated and painted.
   2. Backboard paint color shall be a light gray / off-white.

B. No mechanical/electrical equipment or conduits shall be installed on or across the plywood or impair the routing of telecommunication cables.

C. Fire-retardant stamp to be visible.

3.3 CABLE TRAY

A. Install cable tray in telecommunications room as shown on drawings. Shall be supported at a minimum of every 5’.

B. Install cable tray above all equipment frames and securely attach both ends of cable tray. Cable tray and equipment frame shall be secured so that the top of the equipment frame cannot move. Ladder rack also shall be installed perpendicular to and secured to the outward end of the equipment rack(s).

C. Install horizontal cable tray at a minimum of 7' 0" AFF to the bottom of the tray.

D. Install additional horizontal and vertical sections of cable tray on walls where OSP cables, and large bundles of horizontal cables route from conduits entering/exiting the room.

E. Horizontal cable tray routed within the ER shall be installed in such a way that the route for future "unprotected" OSP cabling does not pass through, on, or in front of the cable tray containing "unprotected" UTP cabling.

3.4 ELECTRICAL OUTLETS

A. Affix thermal label to all electrical outlet covers indicating circuit number and panel of origin.

B. Electrical outlets designated for UPS units located behind equipment frames shall have thermal label indicating reading “UPS only” and contain the circuit number and panel of origin.

C. Electrical outlets designated for service use shall have thermal label indicating reading “Service Use” and contain the circuit number and panel of origin.

D. Each circuit serving the telecommunication room shall have a critical circuit tag affixed adjacent to breaker/switch. Panel schedules/directories shall be labeled to indicate the outlets within the telecommunications room.

3.5 WIRE MANAGEMENT

A. Install D-rings on plywood as specified herein or shown on drawings to support all backbone, riser, and horizontal cabling.

B. Install D-rings horizontally and vertically on plywood backboard to manage horizontal cables that enter the telecommunications room from below up to the cable tray. Route these horizontal cables to the nearest corner of the room to maximize wall space.

END OF SECTION

COMMUNICATIONS CABINETS, RACKS, FRAMES AND ENCLOSURES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This section describes the minimum requirements for the cabinets, racks, frames, and enclosures for Phase II of the Stanley Hall Science Building. The Contractor shall provide racks and enclosures as needed for each system within the project.

B. This section includes the minimum installation requirements for equipment and cabling infrastructure in Equipment Rooms and Telecommunication Rooms, and includes the following:
   1. Floor mounted Equipment Racks
   2. Rack Mounted Power Outlet Units
   3. Uninterruptable Power Supply Units

C. Related Sections include the following:
   1. 27 05 26 - Grounding and Bonding for Communications Systems
   2. 27 05 53 - Identification for Communication Systems
   3. 27 11 19 - Communications Termination Blocks and Patch Panels
   4. 27 15 13 - Communications Copper Horizontal Cabling
   5. 27 11 16 - Communications Cabinets, Racks, Frames and Enclosures

1.2 QUALITY ASSURANCE

A. All telecommunications equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the approval of the Architect and Owners Representative. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based on the acceptable manufacturers listed. Where "Or equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Materials and work specified herein shall comply with the requirements of the local Authority Having Jurisdiction. Refer to Section 27 00 00 for all applicable standards and codes.

1.3 SUBMITTALS

A. Contractors' Bid shall include product data for the all the equipment specified herein.

B. Contractor shall submit shop drawings for the final location and layout of all cabinets and equipment frames before installation.

PART 2 - PRODUCTS

2.1 FLOOR MOUNTED 4 POST EQUIPMENT RACKS

A. Contractor shall provide data equipment racks as shown on the drawings or as specified herein.

B. Acceptable Manufacturers:
   1. Belden 4 Post Steel Rack XDR8419-31236 (84" H x 36")

C. Vertical Wire Management
   1. Provide vertical wire management as shown on the contract drawings and as required herein.
   2. Acceptable Manufacturer:
      a. Belden BHVHH06 (6"W x 84"H) Black

2.2 RACK MOUNTED POWER OUTLET UNITS

A. Provide two (2) power strips per cabinet and rack. Each shall meet the following specifications:
   1. 20 amp, 120V.
   2. Rack mounted, rear facing, and plugged into each AC Power.
   3. Non-switched.
   4. Surge suppressed.
   5. 6 outlets – transformer spaced.
   6. Power cord shall be 10' in length.
   7. Shall meet UL 1363 and 1449 requirements.

B. Acceptable Manufacturers:

1. APC
2. Geist
3. Isobar
4. Interlink
5. Or equal

2.3 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS

A. UPS Units shall meet the following specifications:
   1. Unit shall be network manageable.
   2. Unit shall be a floor mounted tower unit.
   3. Nominal Input and Output Voltage 120V.
   4. Output Power Capacity 2700 Watts / 3000 VA.
   5. Shall meet UL1778 Approval.

B. Acceptable Manufacturer:
   1. APC Smart-UPS 3000VA LCD 120V.
   2. Or approved equal

PART 3 - EXECUTION

3.1 FLOOR MOUNTED EQUIPMENT RACKS

A. The equipment racks shall be installed in the ER/TRs according to layout and communication media requirements. Placement of cabinets shall be done in accordance with the T-Series drawings and/or the approved shop drawing of the room layout. All questions regarding cabinet placement or room layout shall be directed in writing to the Owner.

B. The rack shall be anchored to the floor and braced overhead with ladder racking, and grounded to the ground bus bar location in the ER/TR with a #6 solid or stranded ground wire. All cabinets and racks shall be anchored to the wall.

C. Provide vertical and horizontal cable management as required by this specification or requested by the owner.

3.2 RACK MOUNTED POWER OUTLET UNITS

A. Provide and install each power strip per location as noted on approved shop drawings.

B. Contractor shall label each power outlet per owner requirements to identify all power connections required by owner provided equipment.

3.3 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS

A. Provide and install as in each Telecom Room rack as noted on the drawings.

END OF SECTION

COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

PART 1 - GENERAL

1.1 DESCRIPTION

A. All horizontal cabling shall be terminated in the new ER or TR.

B. This section includes the minimum installation requirements for termination blocks and patch panels in Telecommunication Rooms, and includes the following:
   1. Category 6a Patch Panels
   2. Category 6a Patch Cords
   3. Optical Fiber Patch Cords

C. Related Sections include the following:
   1. 27 11 16 - Communications Cabinets, Racks, Frames and Enclosures
   2. 27 15 13 - Communications Copper Horizontal Cabling
   3. 27 15 43 - Communications Faceplates and Connectors

1.2 QUALITY ASSURANCE

A. All telecommunications equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the approval of the Architect and Owners Representative. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based on the acceptable manufacturers listed. Where "Or equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Materials and work specified herein shall comply with the requirements of the local Authority Having Jurisdiction. Refer to Section 270000 for all applicable standards and codes.

1.3 SUBMITTALS

A. Contractors' Bid shall include product data for the all the equipment specified herein.

PART 2 - PRODUCTS

2.1 CATEGORY 6a PATCH PANELS

A. Contractor shall provide patch panels as shown on the T-Series drawings or as required to complete the project scope.

B. Acceptable Manufacturers:
   1. Belden AX103249 (No Exceptions)

2.2 CATEGORY 6a PATCH CORDS

A. Contractor shall provide a Category 6a patch cords for each terminated data port within the scope of the project. Contractor shall provide Pigtail style cables as required to cross connect each phone location in the project.

B. Length shall be a minimum of 4' and color shall match horizontal cabling. Pigtail cables shall be a minimum of 15'.

C. Acceptable Manufacturers:
   1. Belden 10GX (No Exceptions)

2.3 OPTICAL FIBER PATCH CORDS

A. Contractor shall provide duplex optical fiber patch cords for installation by the Owner.

B. Contractor shall provide four (4) optical fiber patch cords per telecom room. Two shall be multimode and two shall be single mode.

C. Length shall be a minimum of 2 meters and color shall match the type and grade of optical fiber installed.

D. Acceptable Manufacturers:
   1. Belden (No Exceptions)

PART 3 - EXECUTION

3.1 COPPER EQUIPMENT

A. Horizontal Cabling Patch Panels
   1. Use Belden modular angled patch panels filled with black 10GX 6a modules.
   2. Use a Belden Pigtail modular patch cord from the patch panel installed in the rack to the 110 block mounted on the wall for establishing a connection for each phone location.
   3. All patch panels, termination panels, and cable managers should be installed so that their fronts, and the front of the networking equipment later provided by owner, shall be visible from the telecommunications room open doorway.

END OF SECTION

COMMUNICATIONS COPPER BACKBONE CABLING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Work covered by this Section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, and labeling of copper backbone and riser infrastructure as described on the Drawings and/or required by these specifications.

1.2 RELATED SECTIONS

A. The following Sections are related:
1. 27 05 28 - Pathways for Communications Systems
2. 27 05 53 - Identification for Communication Systems
3. 27 11 16 - Communications Cabinets, Racks, Frames and Enclosures
4. 27 11 19 - Communications Termination Blocks and Patch Panels
5. 27 13 23 - Communications Optical Fiber Backbone Cabling
6. 27 15 13 - Communications Copper Horizontal Cabling
7. 27 15 43 - Communications Faceplates and Connectors

1.3 SUBMITTALS

A. Contractors' Bid shall include product data for the all the equipment specified herein.

PART 2 - PRODUCTS

2.1 COPPER BACKBONE CABLING (OUTSIDE PLANT)

A. Provide copper backbone as shown on the contract drawings to the Building Entrance Terminal location in the ER. Cable shall be 100 pairs as required by the Contract drawings.

B. The cable shall be Bell Specification Filled Aluminum Polyethylene (ALPETH) Sheath cable with Dual Expanded Polyethylene (DEPIC) Insulated Conductors.

C. Cable Specification shall be at a minimum:
1. Conductor - Solid annealed copper in 24 AWG.
2. Insulation - Dual expanded high density polyethylene (foam skin) with outer skin color coded in accordance with telephone industry standards.
3. Individual conductors twisted into pairs with varying twists and lay to minimize crosstalk, and specified color combinations to provide pair identification.
4. Assembled in units, each individually identified by color coded unit binders. Prior to the application of the outer sheath, and jacket, the core is completely filled with filling compound that resists moisture penetration.
5. Entire core assembly is filled with an 80°C ETPR compound, filling the air space between the insulated conductors. Cleaning of conductors is not required.
6. Corrugated bare 8 mil aluminum tape is applied longitudinally over the core wrap; inner and outer surfaces of the aluminum shield are flooded.
7. Jacket shall be black, polyethylene.
8. Jacket marking shall be Manufacturer's identification, pair count, AWG, product identification, sequential footage and a telephone handset printed at 2 foot intervals.
9. Compliant with Telcordia GR-421-CORE Issue 2 and RoHS-compliant.
10. Acceptable Manufacturers:
    a. Superior Essex
    b. General Cable
    c. Or equal

2.2 COPPER RISER CABLING

A. Provide riser cables from the ER to the TR as indicated on Drawings or as indicated herein.
1. Riser cables shall consist of 50 or 100 pair unshielded twisted pairs, Jacket Type CMP, #24 AWG, solid copper Category 3, suitable for placement in a plenum space.
2. Acceptable Manufacturer:
    a. Belden (No substitutions)

2.3 BUILDING ENTRANCE PROTECTOR

A. Contractor shall provide a building entrance protector in the Equipment Room as shown on the Drawings.
   1. Building Entrance Terminal shall be available in sizes up to 100 pairs. 100 pair units may be stackable up to 300 pairs.
   2. Shall have integrated protective cover.
   3. Unit shall include a 110 style block output and 110 style input.
   4. Shall meet Telcordia TR-TSY-000299 specifications for performance.
   5. UL Listed with industry standard 5-pin protector solid state modules.
   6. Acceptable Manufacturers:
      a. Circa
      b. Commscope
      c. Emerson Network Power
      d. Or equal

PART 3 - EXECUTION

3.1 GENERAL

A. All Terminating blocks shall be mounted to the wall.

B. Copper riser cables shall be extended to the equipment rack with minimum Category 5e non-bonded pair modular pigtail cables, terminated at the wall on 110 blocks on one end with the Modular Termination plugged into the correct patch panel port for voice service.

C. Cable pairs and 25 pair binder groups shall be cut down in standard color code order.

D. UTP riser cable will have cable ID and pair count clearly marked on building equipment room and punch down blocks.
   1. Copper backbone cabling will be labeled in both the building ER and TR.
   2. Cable IDs will be building number or Name + an underscore + an incremental two digit cable number.
      a. For example, the cable to TR-2 would be 023_01, while the cable to TR-3 would be 023_02.
   3. Counts shall start from the lowest TR number and increment with TR numbers.
      a. For example, the cable to TR-2 would count 023_01, 1-50, while the cable to TR-3 would count 023_02, 51-100.
   4. All labeling must be approved by the appropriate College Information Technology Services personnel.

3.2 TESTING OF COPPER BACKBONE CABLING

A. Perform visual inspection to ensure that all cables are terminated on the punch down block in proper color code order.

B. Test all pairs for continuity and tip and ring polarity.

C. Test results shall meet or exceed the appropriate tests requirements as specified in the ANSI/TIA/EIA-568 specifications.

D. Bad pairs shall be limited to a maximum of 1% of the total number of pairs, and with a maximum of two (2) bad pairs per binder group.

E. Test results shall be stored on a CD and delivered to the College Information Technology Services representative.

F. Test results shall be verified by the designated College personnel as part of the inspection and acceptance procedure.

END OF SECTION

COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Work covered by this Section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, and labeling of optical fiber backbone infrastructure as described on the Drawings and/or required by these specifications.

1.2 RELATED SECTIONS

A. Related Sections include the following:
   1. 27 05 28 - Pathways for Communications Systems
   2. 27 05 53 - Identification for Communication Systems
   3. 27 11 16 - Communications Cabinets, Racks, Frames and Enclosures
   4. 27 11 19 - Communications Termination Blocks and Patch Panels
   5. 27 13 13 - Communications Copper Backbone Cabling
   6. 27 15 13 - Communications Copper Horizontal Cabling
   7. 27 15 43 - Communications Faceplates and Connectors

1.3 SUBMITTALS

A. Contractors' Bid shall include product data for the all the equipment specified herein.

PART 2 - PRODUCTS

2.1 FIBER OPTIC BACKBONE CABLING (OUTSIDE PLANT)

A. Single-mode Fiber Optic Backbone Cable - Provide Singlemode Fiber Optic backbone cables as depicted in the contract Drawings.
   1. Acceptable Manufacturers:
      a. Belden B9W205, 24 strand OS2 Singlemode enhanced backbone cable.

2.2 FIBER OPTIC RISER CABLING

A. Multimode Fiber Optic Riser Cable - Provide Multimode Fiber Optic riser cables from the ER to the TR as indicated on Drawings.
   1. Acceptable Manufacturers:
      a. Belden B9E241, 12 strand 50 micron Multimode OM4 riser cable.

B. Singlemode Fiber Optic Riser Cable - Provide Singlemode Fiber Optic riser cables from the ER to the TR as indicated on Drawings.
   1. Acceptable Manufacturers:
      a. Belden B9W241, 12 strand OS2 Singlemode enhanced riser cable.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install Fiber Optic cables and devices in accordance with industry standards and manufacturer's written instructions.

B. Install Fiber Optic cable without damage to fibers, cladding, or jacket.
   1. Ensure that media manufacturer's recommended pulling tensions are not exceeded.

C. Do not bend cables to smaller radii than the minimums recommended by the manufacturer.

D. Use a pulling means, including fish tape, rope, and basket-weave grips, that will not damage media or raceway. Install Fiber Optic cable simultaneously where more than one cable is being installed in the same raceway.

E. Use pulling lubricant where necessary; compound used must not deteriorate cable materials. Do not use soap.

F. NO splices are allowed. Cable runs to be continuous.

G. Provide grounding connections for Fiber Optic cable and other system components as required by specifications and applicable codes and regulations, according to manufacturer's written instructions.

H. Provide termination of all Fiber Optic cables according to applicable standards and codes.

I. Fiber Optic cable will have cable ID and strand count clearly marked on the fiber cabinet in the ER/TR.

3.2 TESTING OF FIBER CABLES

A. GENERAL

1. It will be the Contractor's responsibility to provide the test equipment necessary and document the campus telecommunication coordinator the test equipment available for testing and the last date of certification.
2. Cables will have SC (OSP) or LC (riser) connectors installed on singlemode cables prior to testing.
3. The tests shall be performed on inter-building and riser fiber cables.
4. Testing Equipment
   a. Continuity tester
   b. Visible fault detector
   c. Power meter and light source
   d. OTDR (Optical Time Domain Reflectometer)
   e. Appropriate types of Fiber Optic jumpers
   f. Equipment for two testers to communicate
   g. Fluke DSP 4000 or equivalent.
   h. Other equipment as approved by designated College personnel and as required to complete the testing to the satisfaction of Earlham College
5. Prior to usage, test equipment and components in accordance with manufacturer's published test procedures.
6. All fibers will be tested bi-directionally per TIA-526-7 and TIA-526-14 method A-2.
7. Bi-directional attenuation figures in decibel (dB) will be documented.
   a. Before testing, verify with the College Information Technology Services representative if raw or referenced readings are preferred.
8. All strands shall test good and meet current ANSI/TIA/EIA-568 specifications. Dark fibers and excessive attenuation due to breaks, bends, bad splices, defective connectors and bad installation practices will not be accepted and must be corrected.
9. Replacement fiber cables shall be subject to tests and criteria as described in this document.
10. All fiber cables shall have NO bad fibers. Fiber cables tested to have bad fibers, and determined to be non-repairable by practices acceptable to the College, shall be replaced at no additional cost to the College.
11. Any and all measures taken to correct unacceptable test results shall be recorded, along with loss measurements taken before and after corrective measures.
12. Documentation will include cable ID, origin and destination points, strand ID, and bi-directional attenuation figures in dB, per TIA Method A-2.
13. Use of an OTDR may require that a "launch reel" be used to overcome the OTDR's dead zone, if needed for fault location if the bi-directional tests fail.
14. Fiber jumpers used with the OTDR, light source and power meter must be of the same size and type of the fiber being tested.
15. Fiber jumpers used with the light source and power meters shall be zeroed out by attaching the jumper from the light source via a coupler to the jumper from the power meter.
    a. This reading noted, it will become the reference level to obtain a true attenuation reading (some power meters can be zeroed to allow reading the attenuation level direct).
    b. TIA-526-7 and TIA-526-14 Method A-2 should be used to zero OLTS.

3.3 LOSS BUDGETS

A. Average splice loss shall not exceed 0.35 dB attenuation for multimode, or 0.25 dB attenuation for single mode, measured from both directions.

B. No individual splice, multimode or singlemode, shall exceed 0.50 dB attenuation, measured from both directions.

C. No termination shall exceed 0.40 dB attenuation for multimode, or 0.30 dB attenuation for single mode. No single mode OSP fiber shall exceed 0.000091436 dB attenuation per foot (0.25 dB attenuation per kilometer) at 1550 nm.

D. Acceptable maximum allowable attenuation per spliced and terminated fiber will be determined by the following formula:

MAX = (S * MS) + (E * ME) + (F * MF)

Where:
S = Number of splices in fiber between end termination points.
MS = dB maximum average allowable attenuation per splice.
E = Number of endpoint terminations (namely, 2).
ME = dB maximum allowable attenuation per endpoint termination.
F = Number of feet of fiber from endpoint termination to endpoint termination.
MF = Manufacturer's specification for maximum allowable fiber attenuation per foot of fiber. (Converted from dB per km by formula - dB per km / 3280.8)

3.4 BACKBONE AND RISER FIBER CABLE TESTING

A. Test multimode riser fiber at 850 nm and 1300 nm in both directions.

B. Test single mode riser fiber at 1310 nm and 1550 nm in both directions is to be used.

C. No multimode riser fiber shall exceed 0.00021336 dB attenuation per foot at 1300 nm, 400 Mhz bandwidth. (0.70 dB attenuation per kilometer at 1300 nm, 400 Mhz bandwidth).

END OF SECTION

AUDIO VIDEO HORIZONTAL CABLING

PART 1 - GENERAL

1.1 WORK INCLUDES

A. Base Bid:
1. Contractor to Provide all work as detailed in the Contract Drawings and Specifications as a turn-key installation, including all material, labor, programming, as-built documentation, warranties, taxes, freight and permits. Only items and requirements specifically stated to be provided under another section shall not be a requirement for this section of the work.
2. Electrical Contractor to provide and install:
a. HDMI Cabling
b. VGA Cabling
c. Balanced Audio Cabling
d. Speaker Cabling
e. XLR Cabling
f. RS232-Control Cabling
g. SF/UTP Cabling

1.2 RELATED DOCUMENTS

A. Related Sections:
1. 27 15 43 - Communications Faceplates and Connectors
2. 27 41 16 - Integrated Audio Video Systems

1.3 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this contract shall be applicable to this contract.

C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the Contract Documents.

1.4 SUBMITTALS

A. Refer to Section 01 for submittal requirements.

1.5 QUALITY ASSURANCE

A. All cable shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the control and approval of the Owner. Equipment and materials shall be of the quality and manufacture indicated. The Equipment specified is based on the acceptable manufacturers listed.

B. The Contractor shall provide in-house engineering and project management capabilities consistent with the requirements of the work. The Contractor shall have a project manager and field supervisor in place which oversees the entire project until completion of the project. The assigned project manager will be responsible for coordination, scheduling, manpower, commissioning etc. of the project. The Contractor's field supervisor shall be present during the full duration of the project to oversee field installations and to coordinate with other trades to ensure progress on the project.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. Electrical contractor shall confirm all faceplate colors, configurations, and labeling prior to installation.

2.2 HDMI CABLING

A. Contractor shall provide HDMI cabling meeting the following specifications:
   1. Minimum 24 AWG construction
   2. Cabling shall be NEC, CMP rated.
   3. Male connector on each end
   4. Minimum resolution of 1080p @ 60 Hz
   5. Max refresh rate of 120 Hz
   6. Minimum data rate of 4.95 Gbps
   7. 24 bit color depth
   8. Acceptable Manufacturers:
      a. C2G
      b. Cable-comm
      c. Comprehensive
      d. Crestron
      e. Extron
      f. FSR
      g. Or Equivalent

2.3 VGA CABLING

A. Contractor shall provide and install VGA cabling meeting the following specifications:
   1. Cabling shall be NEC, CMP rated.
   2. Cabling shall meet or exceed UXGA performance.
   3. Connectors shall be designed for wall box or surface box bulkhead installation.
   4. Minimum 28 AWG construction.
   5. Acceptable Manufacturers:
      a. Conquest
      b. C2G
      c. Comprehensive
      d. Crestron
      e. Hubbell
      f. Or Equivalent
      g. Or Equivalent

2.4 BALANCED AUDIO CABLING

A. Electrical Contractor shall provide and install stereo audio cabling meeting the following specifications:
   1. Cabling shall be minimum 20 AWG, stranded one (1) pair copper.
   2. Overall shield: 100% coverage of aluminum polyester foil with drain wire
   3. Cabling shall be NEC, CMP rated.
   4. Cabling shall carry a balanced audio signal.
   5. Acceptable Manufacturers:
      a. Belden
      b. West Penn

2.5 SPEAKER CABLING

A. Electrical Contractor shall provide and install speaker cabling and appropriate connectors meeting the following specifications:
   1. Cabling shall be NEC, CMP rated.
   2. Cabling shall be minimum 16 AWG, stranded one (1) pair copper.
   3. Plenum rated.
   4. Acceptable manufacturers
      a. Belden
      b. West Penn

2.6 RS-232 CONTROL CABLING

A. Contractor shall provide and install RS-232 control cabling and appropriate connectors meeting the following specifications:
   1. Cabling shall be NEC, CMP rated.
   2. Cabling shall be minimum AWG 20, stranded one (1) pair copper.
   3. Cabling shall be Plenum rated
   4. Acceptable manufacturers:
      a. Belden
      b. Comprehensive
      c. Conquest
      d. Crestron

2.7 SF/UTP CABLING - AV ONLY

A. Contractor shall provide SF/UTP cabling for audio visual and control signals at locations as required by the T-Series drawings.

B. Cabling shall meet the following specifications:
   1. Optimized for use in digital video over twisted pair applications
   2. Certified to a minimum of 450 Mhz bandwidth at distances up to 100 meters.
   3. Nominal pair-to-pair skew shall be no less than 8 nano-seconds per 100 meters and no more than 25 nano-seconds per 100 meters
   4. Fire resistant SF/UTP construction with four unshielded twisted pairs inside and overall braid and foil shield.
   5. NEC, CMP rated outside jacket
   6. Acceptable Manufacturers:
      a. Belden
      b. Extron
      c. Or Equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with Manufacturer’s specifications and published standard’s recommendations.

C. Wiring:
   1. Run wire with conduit, exposed above accessible ceilings, below accessible floors, in cable trays and in riser rooms.
   2. Utilize cable trays whenever possible.
   3. All cabling shall be installed per Owner’s requirements.
   4. Provide plenum rated cable when routed through plenum areas.

5. Provide code compliant fire proofing techniques for all penetrations of fire rated partitions and slabs.
6. Fasten cables securely to building structure every 5 feet at minimum throughout cable paths.
7. Cable runs shall be continuous from device location to the final point of termination.
8. Provide grommets and strain relief material where necessary to avoid abrasion of wire and excess tension on wire and cable.

D. Component Connections:
1. Prepare wire ends for attachment to components in accordance with Manufacturer recommendations.
2. Wire nuts shall not be an acceptable means of connecting wire and cable. All connections shall be made by crimp connection only.

3.2 AUDIO VIDEO CABLING

A. General Requirements
1. Cables are to be installed in flush mounted boxes located at location as shown on the drawings. All patch cords shall be bundled together using hook and loop style cable ties. No zip ties are permitted as cable management.
2. All cables are to be terminated into snap in faceplate inserts and fully connected to all Audio/Visual equipment provided by the Contractor.
3. All faceplates and cabling shall be labeled with appropriate labels as to the source and destination of cabling.

3.3 SYSTEM ACCEPTANCE

A. An authorized representative of the Owner along and the Owner's Representative shall review all audio visual technology components to assure they are properly installed, functional and integrated into the Owner's existing technology infrastructure.

B. All devices shall be reviewed prior to final system acceptance.
1. The Contractor shall provide two (2) weeks advance notification for scheduling of the final system acceptance.
2. The Contractor shall provide two copies of recorded drawings and two copies of completed testing/as built documents.
3. The Contractor shall provide in AutoCAD an electronic version of the recorded drawing documents.

C. Punch list is developed and distributed by the Owner:
1. The Contractor shall produce documentation to demonstrate the punch list has been completed and the installation is at Final Completion.

D. Once the system has been accepted by the Owner, that date will be noted as the start of the warranty period.

E. The Owner reserves the right to suspend and/or terminate testing at any time when the system fails to perform as specified.

END OF SECTION

COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Horizontal cabling is the portion of the UTP cabling system that extends from the work areas to the Equipment Room (ER) or Telecommunications Room (TR). The horizontal cabling shall be configured in a star topology, and include the horizontal cables, the mechanically terminated jacks/inserts and the faceplates in the work areas.

B. Locations of user drops are shown on T-Series Technology Drawings.

C. This section includes minimum requirements for the following:
   1. Category 6a UTP Cable from TR to Workstation.
   2. Installation, Termination, and Testing Methods.

D. Related Sections include the following:
   1. 27 05 53 - Identification for Communication Systems
   2. 27 11 16 - Communications Cabinets, Racks, Frames and Enclosures
   3. 27 11 19 - Communications Termination Blocks and Patch Panels
   4. 27 15 43 - Communications Faceplates and Connectors

1.2 QUALITY ASSURANCE

A. All telecommunications equipment and cabling shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the approval of the Architect and Owners Representative. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based on the acceptable manufacturers listed. Where "Or equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Materials and work specified herein shall comply with the requirements of the local Authority Having Jurisdiction. Refer to Section 270000 for all applicable standards and codes.

C. Strictly adhere to all Category 6a installation practices when installing UTP data cabling.

PART 2 - PRODUCTS

2.1 CATEGORY 6A CABLING

A. Contractor shall provide data cabling from each required outlet location to the ER/TR.

B. All cabling shall be plenum rated. Jacket color shall be blue unless otherwise noted.

C. Acceptable Manufacturers:
   1. Belden Category 6a 10GX13 D151000, Blue (No exceptions).

PART 3 - EXECUTION

3.1 SCOPE OF WORK

A. Before the installation of Horizontal Cabling will be allowed to begin, the telecommunications Contractor must provide a mock-up of the labeling and wiring to a sample faceplate and patch panel.
   1. The mock-ups must be reviewed by an appropriate representative of the College and approved prior to performing any final wiring required by the project documents.

B. Installation of Horizontal Copper Cabling
   1. 4-pair UTP cables should withstand 25 foot-pounds of pulling pressure. This number shall be verified by the wire manufacturer.
      a. Maximum cable length is limited to 90 meters (295 feet) from the jack to the patch panels.
      b. Comply with ANSI/TIA/EIA-569 standard regarding the requirements and recommendations for separation of copper telecommunication cabling from sources of electromagnetic interference.
      c. The Contractor shall replace any damaged cable at no expense to the College. No repair will be allowed on damaged cables.
   2. Cabling shall be terminated at the station jack and at the equipment room as indicated in ANSI-TIA-EIA-568, wiring configuration T568B.

a. The modular faceplate at the user end shall be equipped with inserts for communication services as indicated on plans.
b. Station cable in the TR shall be terminated on Category 6a patch panel located in the equipment racks.
c. The minimum bend radius of Category 6a UTP cable shall not be smaller than four (4) times the diameter of the jacketed cable, and shall not cause the cable jacket to buckle.
d. Route cables from the back of the patch panel through its coupler openings and loosely attach them to the wire manager with Velcro cable ties, leaving enough slack for re-termination at a future date.
e. Remove only as much jacketing as needed to terminate properly to the connecting hardware, keeping the amount of jacketing removed to an absolute minimum.
f. Do not untwist pairs more than 0.5 inches.
g. Visually inspect cable pairs for bare wire and other defects before terminating wires.
h. Once all of the cables have been terminated, dress the cable slack behind the panel with Velcro tie wraps tightened to a snug but not compressing fit.

3. Telecommunication cabling for elevator emergency phones shall be provided as follows:
a. Cabling for the elevator telephone to the elevator control room is by the elevator installer.
b. Cabling from the elevator control room to the ER is by the low voltage contractor. Jack must be mounted adjacent to, but outside of the elevator electrical panel.
c. The electrical contractor shall notify campus personnel of the elevator service date. This notification for request of services shall be provided no fewer than 21 days prior to service.

C. Testing of Horizontal Copper Cabling
1. Perform visual inspection to ensure that all cables are terminated on the eight position station jacks on both ends in proper color code order.
2. All terminated cabling runs shall be 100% tested for defects in installation and to verify cabling system performance under installed conditions according to the requirements found in the TIA/EIA-568-C series of standards. All pairs in each installed cable shall be verified prior to system acceptance. Any defect in the cabling system installation, including (but not limited to) cables, connectors, patch panels, and cordage shall be repaired or replaced in order to ensure 100% usability of all installed runs.
3. All balanced twisted-pair cable links shall be tested for basic continuity and length, as indicated below. Of the parameters listed, it is understood that PSANEXT cannot be tested using current field test equipment.
4. Continuity – Each pair in every installed cabling run shall be tested using a test set that detects and identifies opens, shorts, polarity and pair reversals, crossed pairs, and split pairs. The results shall be recorded as Pass/Fail (as indicated by the test set) and referenced to the appropriate cable identification number and circuit/pair number. Any fault shall be corrected and the run re-tested prior to final acceptance.
5. Length – Every installed cabling run shall be tested for installed length using a time domain reflectometer (TDR) device. The cable length shall not exceed 90m (295 ft). The cable length shall be recorded, referencing the cable identification number and circuit/pair number.
6. Category 6a performance testing shall be done according to the published standards.
7. The approved handheld tester will have the capability to be programmed with current Category 6a requirements as specified in ANSI/TIA/EIA-568 standards.
8. Documentation will include cable ID (same as jack ID) to be marked on the punch down blocks and patch panels in the telecommunication closet, station jack ID to be marked on the station jack and results of the testing done with the cable analyzer.
9. Analyzer documentation will also need to be in the "csv" or "dat" format.
a. Results must be labeled using the information outlet labeling scheme for the project.
10. Test results shall be stored on a CD and delivered to the College's Information Technology Services representative.
11. Test results shall be verified by the designated College personnel as part of the inspection and acceptance procedure.

D. Warranty and Certification
1. In order to facilitate quicker turn-around for ordering and activating new information outlets in the building, the telecommunications Subcontractor shall submit partial jack lists that are tested and approved rather than submitting the lists and test results of the entire building.

2. The installed Belden IBDN System 10GX shall be covered by Belden IBDN System Certification, issued by Belden Inc. and delivered by the CSV.
3. To qualify for System Certification, the Belden IBDN System 10GX shall be designed, installed, and tested by a CSV.
4. To qualify for System Certification, the installed cabling system shall fully comply with all relevant Belden IBDN design and applications guidelines, including any pre-approved deviations as specified in the latest release of the Belden IBDN Certification Guide.
5. To qualify for System Certification, only products made or approved by Belden Inc. shall be used to ensure the end-to-end performance of the Belden IBDN System 10GX. The Belden Inc. 25 Year Component Warranty and Lifetime Application Assurance can only be provided to installations consisting of products supplied by Belden Inc. for the Belden IBDN System 10GX.
6. The Belden IBDN System Certification shall provide a twenty-five (25) year warranty for all Belden IBDN passive components used in the installed Belden IBDN System 10GX. Defective and/or improperly installed products shall be replaced and/or reinstalled at no cost to the owner of the Belden IBDN System 10GX.
7. The Vendor shall provide a Belden IBDN User Manual to the owner of the Belden IBDN System 10GX. This document describes essential system elements and specifies the Owner's responsibilities for maintaining the integrity of the installed cabling system over time. The Belden IBDN User Manual contains guidelines for cabling system modifications (e.g., relocations, additions, changes to services), in addition to labeling and record-keeping maintenance requirements.

END OF SECTION

COMMUNICATIONS FACEPLATES AND CONNECTORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes the minimum requirements for the installation, termination, and labeling of the faceplates and connectors as depicted on the Drawings and required by these specifications.

B. This section includes minimum requirements for the following:
   1. Category 6a Jacks
   2. VGA Coupler
   3. 3.5mm Audio Coupler
   4. HDMI Coupler
   5. SF/UTP Female Keystone Jacks
   6. Faceplates

C. Related Sections include the following:
   1. 27 05 28 - Pathways for Communications Systems
   2. 27 11 16 - Communications Cabinets, Racks, Frames and Enclosures
   3. 27 11 19 - Communications Termination Blocks and Patch Panels
   4. 27 15 00.23 - Audio-Video Communications Horizontal Cabling
   5. 27 15 13 - Communications Copper Horizontal Cabling

1.2 QUALITY ASSURANCE

A. All telecommunications and audio visual equipment and cabling shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the approval of the Architect and Owners Representative. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based on the acceptable manufacturers listed. Where "Or equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Materials and work specified herein shall comply with the requirements of the local Authority Having Jurisdiction. Refer to Section 270000 for all applicable standards and codes.

1.3 SUBMITTALS

A. Manufacturers catalog sheets, specifications and installation instructions for all products to be installed within the scope of work included under this contract shall be submitted for approval.

PART 2 - PRODUCTS

2.1 CATEGORY 6A JACKS

A. Contractor shall provide the quantity of Category 6a jacks required by the contract drawings for the project. Provide jacks in faceplates in work areas as well as ER and TR locations as needed.

B. Acceptable Manufacturers:
   1. Belden 10GX, Keyconnect Style (No Exceptions)
      a. Acceptable Colors:
         1) Blue
         2) Orange (CCTV and WAP locations only)

2.2 STANDARD INFORMATION OUTLET FACEPLATES AND INSERTS

A. Contractor shall provide the quantity of faceplates and inserts required by the contract drawings for the project. The following are the standard faceplates and inserts for the project.
   1. Belden Media Flex Plate 1-Gang, Color Determined by Architect (No Exceptions)
   2. Belden Media Flex Plate 2-Gang, Color Determined by Architect (No Exceptions)
   3. Belden blank module inserts, Color Determined by Architect (No Exceptions)
   4. Compatible VGA Coupler Insert
   5. Compatible HDMI Insert
   6. Compatible 3.5mm Audio Insert
   7. Compatible S/FUTP Keystone Female Jack for UTP AV cabling

2.3 SURFACE MOUNT BOX LOCATIONS

A. Contractor shall provide surface mount boxes only as shown on the T-Series drawings. Any other locations shall be clarified with the Owner before use.

B. Single Port Surface Mount Box
   1. Belden AX104132 Surface Mount Box

C. Four Port Surface Mount Box
   1. Belden AX104134 Surface Mount Box

2.4 GROMMET FACEPLATES

A. Contractor shall provide grommet faceplates as needed for audio and video locations throughout the project.

B. Grommet faceplates shall provide a minimum of 1.5” Diameter opening for cable pass through.

C. Faceplates shall be provided to match all other device faceplate locations.

PART 3 - EXECUTION

3.1 GENERAL

A. All cables shall be terminated with high density modular jacks that snap into a faceplate mounted on a wall outlet box or surface raceways.

B. Outlet boxes shall be secured to the building with mechanical fasteners. Adhesive fasteners are not allowed.

C. All openings not used shall be filled with appropriate blank inserts.

D. All locations including Audio Video connectors shall be labeled as to its purpose and/or destination. Confirm labeling with Architect and Owner before final installation.

3.2 INFORMATION OUTLET ROUGH-IN

A. Standard Information Outlets (single gang or double gang) shall be located at the same height as 120 volt AC outlets (normally 18" above finished floor).

B. Wall mounted telephones require a double gang box with a single gang plaster ring, positioned 54" A.F.F. to the center of the outlet box.

C. Information Outlets above countertops should be installed so that the center of the outlet box will be a minimum of 12" above the countertop.
   1. A countertop with a backsplash may require different outlet box locations.

D. No Information Outlet will be installed such that workstations or devices served from it cannot be reasonably reached by a 16ft cord.

3.3 LABELING

A. Contractor shall complete labeling according to section 27 05 53 - Identification for Communications Systems.

END OF SECTION

INTEGRATED AUDIO VIDEO SYSTEMS AND EQUIPMENT

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This section includes the minimum requirements for the installation, configuration, and training of the audio visual components as depicted on the Drawings and required by these specifications.

B. This section includes minimum requirements for the following:
1. Flat Panel Displays
2. Short Throw Projectors
3. Ceiling Mounted Projectors
4. Retractable Projector Screens
5. Audio Video System Control Panel
6. Audio Video System Control Touchpanel
7. HDMI Output Scaling Presentation Switchers
8. DTP Output Scaling Presentation Switchers
9. Audio Amplifiers
10. 70V Mixer Amplifiers
11. Ceiling Mounted Speakers
12. Wireless Microphone Systems
13. Blu-Ray Players
14. Audio Video Lecterns
15. Lesson Capture System
16. Document Cameras
17. UTP Distribution System
18. Modular Matrix Switcher

C. Related Sections include the following:
1. 27 05 28 - Pathways for Communications Systems
2. 27 11 16 - Communications Cabinets, Racks, Frames and Enclosures
3. 27 11 19 - Communications Termination Blocks and Patch Panels
4. 27 15 00.23 - Audio Video Communications Horizontal Cabling
5. 27 15 13 - Communications Copper Horizontal Cabling
6. 27 15 43 - Communications Faceplates and Connectors

1.2 QUALITY ASSURANCE

A. All cable shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Architect. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "Or equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Materials and work specified herein shall comply with the requirements of the local Authority Having Jurisdiction. Refer to Section 270000 for all applicable standards and codes.

1.3 SUBMITTALS

A. Manufacturers' catalog sheets, specifications and installation instructions for all products to be installed within the scope of work included under this Contract shall be submitted for approval.

B. Test Results and Documentation as per Section 270553 - Identification for Communications Systems.

PART 2 - PRODUCTS

2.1 FLAT PANEL DISPLAYS

A. Contractor shall provide and install flat panel displays as shown on the T-series drawings.

B. Flat panel displays shall meet or exceed the following specifications:
1. Shall support resolutions up to and including 1920 x 1080 or higher.
2. Acceptable Manufacturers:
a. Samsung
b. Sharp

c. Panasonic
d. Or equal
3. LED Display Technology.
4. Minimum brightness of 400 cd/m² (nits).
5. Aspect ratio of 16:9.
6. Minimum viewing angle of 176° vertically and horizontally.
7. Designed for continuous operation 24 hours a day, 7 days a week.
8. Maximum power consumption 200W.
9. Ethernet connectivity.
10. RS-232 control.

2.2 SHORT THROW PROJECTORS

A. Contractor shall provide and install short throw projectors as shown on the T-series drawings.

B. Short throw projectors shall meet or exceed the following specifications:
1. Shall be wall mountable.
2. Shall support resolutions up to and including WXGA (1280 x 800) or higher.
3. Shall accept VGA and HDMI input.
4. RS-232 control
5. Acceptable Manufacturers:
a. Epson 485W (No exceptions)

2.3 CEILING MOUNTED PROJECTORS

A. Contractor shall provide and install ceiling mounted projectors as shown on the T-series drawings.

B. Ceiling mounted projectors shall meet or exceed the following specifications:
1. Shall support resolutions up to and including WXGA (1280 x 800) or higher.
2. Minimum of 4000 lumens of brightness
3. Shall accept VGA and HDMI input.
4. RS-232 control
5. Acceptable Manufacturers:
a. Epson Powerlite 1945W
b. Or equal

2.4 RETRACTABLE PROJECTOR SCREENS

A. Contractor shall provide and install retractable projector screens as shown on the T-series drawings.

B. Retractable projector screens shall meet or exceed the following specifications:
1. Shall be recessed ceiling mount model.
2. Shall include 110-120V motor with 3 position wall mounted up/down/stop controls.
a. Faceplate and switch colors shall be approved by the Architect.
3. Shall be 16 x10 aspect ratio with a minimum 102" wide viewing area.
4. Unit shall include RS-232 control to enable control of the screen by the Audio Video control system.
5. Case color shall be white.
6. Screen shall be tab-tensioned.
7. Screen material shall be matte white.
8. Screen shall have a minimum gain of 0.8 from all viewing angles.
9. Acceptable Manufacturers:
a. Da-Lite
b. Draper
c. Or equal

2.5 AUDIO VIDEO SYSTEM CONTROL PANEL

A. Contractor shall provide, install and program audio video system control panels as shown on the T-series drawings.

B. Control Panels shall meet the following specifications:
1. Ethernet monitoring and control
2. Mountable in a standard 3-gang wall box
3. Two bidirectional serial ports

4. Three unidirectional serial/IR control ports
5. Six relays
6. Acceptable Manufacturers:
    a. Extron MLC226 IP (No exceptions)

2.6 AUDIO VIDEO SYSTEM CONTROL TOUCHPANEL

A. Contractor shall provide, install and program audio video system control touchpanels as shown on the T-series drawings.

B. Touchpanels shall meet the following specifications:
1. Minimum screen size of 7" diagonal with widescreen aspect ratio
2. Minimum resolution of 800 x 480
3. Minimum brightness 400 cd/m² (nits)
4. Wall mountable
5. Acceptable Manufacturer:
    a. Extron (No exceptions)

2.7 HDMI OUTPUT SCALING PRESENTATION SWITCHERS

A. Contractor shall provide and install scaling presentation switchers as shown on the T-series drawings.

B. Scaling presentation switchers shall meet or exceed the following specifications:
1. Shall be capable of accepting analog and digital video input.
2. Minimum of six inputs.
3. Shall be rack mountable.
4. Acceptable Manufacturers:
    a. Extron IN1606 (no exceptions)

2.8 DTP DMI OUTPUT SCALING PRESENTATION SWITCHERS

A. Contractor shall provide and install scaling presentation switchers as shown on the T-series drawings.

B. Scaling presentation switchers shall meet or exceed the following specifications:
1. Shall be capable of accepting analog and digital video input.
2. Minimum of eight inputs.
3. Shall be rack mountable.
4. Shall be capable of transmitting audio and video over UTP cabling.
5. Shall include a mono audio amplifier.
6. Acceptable Manufacturers:
    a. Extron IN1608 MA (no exceptions)

2.9 AUDIO AMPLIFIERS

A. Contractor shall provide and install an audio amplifier within each ceiling mounted enclosure as required by the T-series drawings.

B. Amplifiers shall meet the following specifications:
1. Minimum two inputs
2. Mono output
3. RS-232 controllable
4. Acceptable Manufacturer:
    a. CTS-AMP-32W-232
    b. Or approved equal

2.10 70V MIXER AMPLIFIERS

A. Contractor shall provide and install 70V Amplifiers as shown on the T-series drawings.

B. 70V Amplifiers shall meet or exceed the following specifications:
1. Minimum 250W continuous power
2. Minimum 2 balanced XLR inputs
3. Rack mountable
4. Capable of integration with audio video control system
5. Acceptable Manufacturers:

a. Crown
b. Peavy
c. Pyle
d. Or equal

2.11 CEILING MOUNTED SPEAKERS

A. Contractor shall provide and install flush mounted ceiling speakers in locations shown on the T-series drawings.

B. Ceiling mounted speakers shall meet or exceed the following specifications:
1. Minimal speaker diameter of 6”
2. Minimum frequency response range of 75Hz to 20kHz
3. Minimum Sensitivity of 89 db SPL, 1W @ 1m (3.3 ft)
4. Shall have back baffles and tile bridges.
5. Shall have a power capacity of no less than 150 watts.
6. Shall have a nominal impedance of 8 ohms.
7. 70V tap with multiple settings
8. Acceptable Manufacturers:
a. Atlas
b. Electro-Voice
c. JBL
d. Or equal

2.12 WIRELESS MICROPHONE SYSTEM

A. Contractor shall provide and install a wireless microphone system as shown in the T-series drawings
B. Wireless microphone system shall meet or exceed the following specifications:
1. Minimum 100 ft operating range
2. On-off switch on transmitter
3. Rack mountable receiver
4. Acceptable Manufacturers:
a. Shure
b. Behringer
c. Sennheiser
d. Or equal

2.13 BLU-RAY PLAYERS

A. Contractor shall provide and install Blu-Ray players as shown in the T-series drawings.
B. Blu-Ray players shall meet or exceed the following specifications:
1. RS232 control
2. HDMI output
3. Rack mountable
4. Acceptable Manufacturers:
a. Samsung
b. Sony
c. Pioneer
d. Or equal

2.14 AUDIO VIDEO LECTERNS

A. Contractor shall provide and install audio video lecterns as shown in the T-series drawings
B. Lecterns shall meet or exceed the following specifications:
1. Minimum 24 RU
2. Customizable with different audio video connector plates
3. Integrated shelf or drawer for document camera
4. Integrated cable management
5. Available with furniture style finishes
6. Capable of being mounted on a wheeled base for mobility where required
7. Acceptable Manufacturers

a. Middle Atlantic
b. Spectrum
c. Or equal

2.15 LESSON CAPTURE SYSTEM

A. Contractor shall provide and install lesson capture systems as shown in the T-series drawings
B. Lesson capture system shall meet or exceed the following specifications:
1. Live and on-demand streaming
2. DVI + 3.5mm,HDMI, or HD-SDI capture input
3. Minimum of 30 frames per second of video capture
4. Support HD capture resolution up to and including 1080p
5. Capture unbalanced stereo analog audio
6. RS-232 Input for control system integration
7. Minimum 500Gb on-board storage, or external storage connection.
8. Acceptable Products:
a. Haivision Viper
b. Sonicfoundry Mediasite RL Recorder
c. Epiphan Recorder Pro HD Compact
d. Or equal

2.16 DOCUMENT CAMERAS

A. Contractor shall provide and install document cameras as shown in the T-series drawings
B. Document cameras shall meet or exceed the following specifications:
1. A minimum video frame rate of 30 frames per second
2. RS232 control
3. HDMI or VGA output
4. Minimum WXGA resolution
5. Acceptable Manufacturers:
a. Elmo
b. Wolfvision
c. Or equal

2.17 UTP TRANSMITTERS

A. Contractor shall provide and install UTP transmitters and receivers as shown in the T-series drawings
B. UTP distribution system components shall meet or exceed the following specifications:
1. UTP transmitter switcher shall accept VGA + 3.5mm, and HDMI inputs as required in each space
2. UTP transmitter shall have RS-232 control
3. Acceptable Manufacturers:
a. Extron
b. Crestron
c. Or equal

2.18 XTP MODULAR MATRIX SWITCHERS

A. Contractor shall provide and install XTP modular matrix switchers as shown in the T-series drawings
B. Modular matrix switchers shall meet the following specifications:
1. Fully digital signal routing
2. 15.2 Gbps data-rate backplane
3. Fully configurable with input and output boards
4. RS-232 insertion from the Ethernet control port
5. Acceptable Products:
a. Extron XTP Crosspoint series (No exceptions)

2.19 XTP SCALING RECEIVERS

A. Contractor shall provide and install XTP scaling receivers as shown in the T-series drawings.

B. XTP scaling receivers shall meet the following specifications:
1. Receives video, audio, and RS-232 over S/FUTP cabling

2. HDMI output
3. Selectable output resolutions
4. HDCP compliant
5. Remote power capabilities
6. Plenum rated
7. Acceptable Manufacturers:
    a. Extron XTP SR HDMI

PART 3 - EXECUTION

3.1 FLAT PANEL DISPLAYS

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the flat panel displays.

B. Displays shall be mounted utilizing Chief LSMU Large FUSION Fixed Wall mounts.

C. Display size and mounting height shall be as follows for each location:
1. Science Commons Lobby - Room 100 (100-A1 and 100-B1):
    a. Display size shall be 55" class.
    b. Top of display shall be at 6' 6" above finished floor.
2. Circulation Desk - Room 102 (102-B1):
    a. Display size shall be 55" class.
    b. Top of display shall be at 6' 6" above finished floor.
3. Corridor 710 (710-B1):
    a. Display size shall be 46" class.
    b. Top of display shall be at 6' 6" above finished floor.
4. Corridor 720 (720-A1):
    a. Display size shall be 46" class.
    b. Top of display shall be at 6' 6" above finished floor.
5. Corridor 731 (731-A1):
    a. Display size shall be 46" class.
    b. Top of display shall be at 6' 6" above finished floor.

3.2 SHORT THROW PROJECTORS

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the short throw projectors.

B. Shall be mounted so that the top of the projected image is at 90" A.F.F.

C. Shall be connected as shown on the T-series drawings.

3.3 CEILING MOUNTED PROJECTORS

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the ceiling mounted projectors.

B. Shall be mounted to provide the desired image size with minimal post-installation adjustment.

C. Image size shall be 64" x 102", with the bottom of the projected image at 4' 0" A.F.F.

D. Shall be wired as shown on the T-series drawings.

3.4 RETRACTABLE PROJECTOR SCREENS

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the retractable projector screens.

B. Screens shall be provided with extra black material at the bottom of the screen such that the bottom of the screen shall be at or below 29" A.F.F., with the bottom of the viewing area being at 48" A.F.F.

3.5 SCALING PRESENTATION SWITCHERS

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the audio video switcher.

B. Switchers shall be rack mounted.

C. Switchers shall be connected as shown in the T-series drawings.

3.6 AUDIO AMPLIFIERS

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the audio amplifiers.

B. Audio amplifiers shall amplify audio signal from scaling presentation switcher and output a mono signal to the speakers within the room.

3.7 70V MIXER AMPLIFIERS

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the 70V amplifiers.

B. Mixer amplifiers shall combine and amplify source audio content and microphone feed and output a mono signal to speakers within the room.

C. Mixer amplifiers shall be connected as shown in the T-series drawings.

3.8 CEILING MOUNTED SPEAKERS

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the ceiling speakers.

B. Shall be wired in parallel according to Manufacturer specifications.

C. Tap settings shall be determined in the field and provided to the Architect for approval.

D. All speaker cabling shall be supported above the ceiling and may not rest on ceiling tiles.

E. A minimum five (5) foot service loop shall be provided and secured above each speaker.

3.9 WIRELESS MICROPHONE SYSTEMS

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the wireless microphone systems

B. Contractor shall coordinate with Owner to verify quantity and types of wireless microphones for each space.

3.10 BLU-RAY PLAYERS

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the Blu-Ray players.

3.11 AUDIO VIDEO LECTERNS

A. Contractor shall follow all Manufacturer requirements and recommendations for the assembly and installation of the audio video lecterns.

B. Contractor shall provide all adaptor plates and connectors necessary to accommodate all sources required by the T-series drawings for each space.

C. Contractor shall confirm final location of lectern within room with Owner prior to installation.

3.12 LESSON CAPTURE SYSTEM

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the lesson capture system.

B. Lesson Capture System shall be wired as shown in the T-series drawings, and connected to the audio video control system via RS-232

C. Lesson Capture System shall be connected to Earlham’s network for uploading of video.

D. Lesson capture HDMI or HD-SDI input shall have embedded audio signal, DVI input shall include 3.5 mm stereo audio cabling for capturing audio.

3.13 DOCUMENT CAMERAS

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the document cameras.

B. Document cameras shall be connected as shown in the T-series drawings.

3.14 UTP TRANSMITTERS

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the UTP transmitters.

3.15 XTP MODULAR MATRIX SWITCHERS

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the matrix switchers.

B. Switchers shall be rack mounted.

C. Contractor shall provide all input and output boards required to receive all sources and output to all displays within each system as shown in the T-series drawings.

3.16 XTP SCALING RECEIVERS

A. Contractor shall follow all Manufacturer requirements and recommendations for the installation of the XTP scaling receivers.

B. Contractor shall install one receiver for each display within each system as shown on the T-series drawings.

3.17 SYSTEM ACCEPTANCE

A. Contractor shall demonstrate to the Owner that all systems have been installed per the plans and specifications and that all programming functions, display functions, control functions and all interfaced equipment operate as expected.

B. Contractor shall demonstrate to the Owner that all the end user staff has a working knowledge of how to operate the installed equipment and that the facilities staff also has a working knowledge of the troubleshooting methods for non-critical service problems.

C. Contractor shall have a Delivery and Acceptance form signed by the Owner representative, agreeing that the installation is complete and its operation is acceptable except as noted on the Delivery and Acceptance form. This will also serve as the start of the warranty period.

D. Contractor shall work with the General Contractor to complete all punch lists and work required to allow the General Contractor to close out his project in a timely manner. This will include but not limited to any work that would impact any final inspection for turnover of the building.

END OF SECTION

ACCESS CONTROL SYSTEM

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The work required under this section consists of providing labor, equipment, supplies, materials, testing unless otherwise specified, and to perform the following operations recognized as necessary for the installation, termination, labeling, of conduits, boxes, raceways, etc., and the wiring of the Access control system. Access control wiring includes cables for doors, card readers, door contacts, door latches, and electric strikes.

1.2 RELATED SECTIONS

A. Related sections include the following:
   1. 08 70 00 - Door Hardware
   2. 26 00 00 - Electrical
   3. 27 00 00 - Communications

1.3 INTENT OF DRAWINGS AND SPECIFICATIONS

A. These Specifications, together with the Drawings accompanying them, are intended to depict the installation requirements necessary to support this Project. Contractor shall furnish materials shown and/or called for on the Drawings but not mentioned in the Specifications, or vice versa, that are necessary for the installation and support of communications cabling, whether or not specifically called for in both. In addition, Contractor shall provide incidental equipment and materials required for the completion of systems included in this contract whether or not specified or shown on the Drawings.

1.4 DEFINITIONS

A. Door Switch – Flush mounted magnetic switch installed at the top of the door frame near the side opposite to the hinges that is connected back to card reader control board.

B. Controlled Door– Any door consisting of at least (1) door switch that is being monitored with central CBORD system board but without a card reader near the monitored door

C. Card Reader Door- Any door consisting of at least (1) card reader and that is monitored by the central CBORD system board.

D. LX Switch – Switch located in panic bar mounted on door or inside a mortise type latch to monitor position of the latch.

E. RX Switch – Switch located in magnetic lock panic bar mounted on door to monitor position of the panic bar (Request to Exit).

F. Power Transfer – Device connected to the door, on hinged side, and to the door frame for the purpose of transferring wires from the door frame to the door for monitoring and controlling the latches.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Detail the system including the following:
   1. Cabling Diagrams: Single-line block diagrams showing cabling interconnection of all components for this specific equipment.
   2. Wiring Diagrams: Detail power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring. Identify terminals.
   3. Equipment Cabinet Drawings: Dimensioned and to scale.

C. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements. On request, submit evidence of experience and of relationship with equipment manufacturer.

D. Manufacturer Certificates: Signed by manufacturers certifying that they comply with requirements.

E. Field Tests Reports and Observations: Include record of final adjustments certified by Installer.

F. Maintenance Data: Include the following in maintenance manuals specified in Division 1:
   1. Operating instructions
   2. Troubleshooting guide
   3. Wiring terminal identification

4. Equipment parts list

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of the product manufacturer for both installation and maintenance of units required for this Project. The installer shall have a minimum of three (3) years documented experience installing and servicing access control systems.

B. Manufacturer Qualifications: A firm experienced in manufacturing equipment similar to that indicated for this Project and that maintains technical support services capable of providing user with training, parts, and emergency maintenance and repair with a 24-hour- maximum response time. The manufacturer of the product specified in this section shall have a minimum of five (5) years of documented experience in the manufacture and design of access control systems.

C. Source Limitations: Obtain security equipment components through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled according to UL 1069 as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. The access control system shall conform to all local and state jurisdiction requirements.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Card Readers: Furnish quantity equal to 10 percent of amount installed, but not less than 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by:
1. The CBORD Group, Inc.
61 Brown Road
Ithaca, NY 14850

2.2 SYSTEM REQUIREMENTS

A. Coordinate the features of materials and equipment to form an integrated system. Match components and interconnections for optimum performance of specified functions.

B. Resistance to Electrostatic Discharge: System, components, and cabling, and the selection, arrangement, and connection of materials and circuits, shall be protected against damage or diminished performance when subjected to electrostatic discharges of up to 25,000 V in an environment with a relative humidity of 20 percent or less.

C. Equipment: Solid state, modular.

D. Wall-Mounted Component Connection Method: Components connect to system wiring in back boxes with factory-wired plug connectors.

2.3 ACCESS CONTROL SOFTWARE

A. The access control software shall be interfaced with and control the access points, monitor input points, and relay controlled outputs as indicated on the drawings and further described in this technical specification.

B. The access control software shall meet the following, minimum, design and performance specifications:
1. Software shall enable the Owner to pre-populate the access control database from existing Owner-controlled user data that is maintained in software programs supporting any popular data output format.
2. Software shall provide and utilize “wizard” style interactive guidance to allow the system administrator or operator to perform standard configuration tasks in a step-by-step process.
3. Software shall support digital interfacing between other security systems, as required by design and shown on the drawings, such as digital video recorders, intercom systems, and CCTV switchers.

4. Software shall support the capture of cardholder images and the creation of photo ID badges integrated completely within the software application.
5. Software shall support twenty (20) user-defined data fields, in addition to those required by the system for basic cardholder management.
6. Software shall support 256 user-defined macros to allow system activities and events to trigger pre-configured actions.
7. Software shall allow system operators to monitor operator-selected doors in order to perform cardholder verification. With each card transaction, the stored image associated with that card will be immediately displayed on the operator workstation.
8. Software shall support the monitoring of input points at selected areas, as shown on the drawings, to provide alarm or event monitoring of these points and report changes in status for these input points to the operator through a real-time display.
9. Software shall support the control of elevator floor selection, where required by design and as indicated on the drawings, through associated field hardware.
10. Software shall support output control relays at selected areas, as shown on the drawings, to control external devices and interface with other systems.
11. Software shall support alarm and event filtering to allow user-defined exceptions to normal alarm and event displays to system operators.
12. Software shall support graphical maps displayed on selected system workstations to indicate the location of events, alarms, and system field devices on site specific maps. Each graphic or icon will be interactive to allow operator to select associated commands for that device from the directly from the icon.
13. Software shall support precision access to allow each cardholder to be provided access privileges to specific doors in addition to any doors included in their assigned access code.
14. Software shall interface with common radio paging services and email servers to enable system alarms, events, and other notifications to be transmitted to pre-selected pagers and email recipients.
15. Software shall include a custom report designer to allow the creation of user-defined reports.
16. Software shall archive all events in a system event file and retain all of the current events until an archive is performed.

C. The access control software shall be capable of the following functions.
1. Software shall support, and operate on, an unlimited number of workstations.
2. Software shall support unlimited system users. Each system user may be defined specific privileges to perform software application functions.
3. Software shall interface with, and support, up to eight (8) system control processors (SCP).
4. Software shall interface with, and support, a combination of up to 4,096 input points and output relays.
5. Software database shall have the capacity for unlimited card holders.
6. Software shall be licensed for a minimum of 512 card readers as indicated on the drawings.
7. Software shall support up to 32,000 access levels and allow up to thirty- two (32) access codes to be assigned to any single card holder.
8. Software shall support up to 255 time zone definitions capable of being associated with access codes or door command functions.
9. Software shall support up to two hundred and fifty-five (255) holiday definitions of variable duration that may be grouped to associate with time zone exceptions on specific dates defined as holidays.
10. Software shall interface with, and support, up to sixty-four (64) elevator floors through the configuration of up to 255 elevator floor codes.

D. The access control software shall be as provided by CBORD. Earlham College has software installed on a central server and all new access control locations shall integrate with existing software. Contractor shall provide licenses for each access control or monitoring location as needed.

2.4 SINGLE DOOR CONTROLLER

A. Contractor shall provide a single door controller per door location as required.

B. Acceptable Manufacturers:
1. CBORD Squadron One Door Controller (Controller-Only Version)

2.5 ACCESS CONTROL CARD READERS

A. Contractor shall provide access control card readers as required by the contract drawings.

B. Reader shall be capable of reader both a magnetic stripe and proximity card credential.

C. Acceptable Manufacturers:
   1. CBORD CS Access Combination Reader

2.6 MAGNETIC DOOR POSITION SWITCH (DPS)

A. The standard recessed door position switch shall be GE Interlogix 1078C series or approved equivalent. The contact and the magnet shall be hermetically sealed in a one piece, molded, flame retardant ABS plastic housing for maximum strength and durability. The contact and magnet shall snap-lock into a predrilled 3/4" diameter hole. Color of the housing shall be off white, gray, or mahogany, and shall be provided in the appropriate color to match the door and doorframe. The magnet shall be made of Alnico V. For delayed egress doors with card access, the recessed door position switch shall be a GE Interlogix 1076D (DPDT).

B. On double doors where each leaf has a DPS, the devices shall be wired in series. Both sensors shall report alarms to the system as a single alarm point

2.7 REX MOTION SENSORS

A. The Request to Exit Motion Detector specified herein shall provide a means of shunting the Door Monitor Switch and/or the unlocking of the controlled door upon exiting.

B. The REX motion sensor shall be a single device capable of controlling single or dual leaf doors. The unit shall be ceiling or wall mountable and have adjustable patterns. The unit shall have an LED activity indicator. The device shall have two (2) Form-C relays for outputs.

C. The REX motion sensor shall be a Bosch DS150i or approved equivalent.

2.8 CABLES

A. RS485 Communication Wire - Provide communication cables from Main Access Control Cabinet to each card reader and controlled device.
   1. Each RS485 cable shall be a 2-pair, individually shielded, 22 gauge, stranded polypropylene insulated conductors, with (1) 24 gauge stranded tinned copper drain wire and overall chrome PVC jacket, UL CM rated.
   2. Manufacturer shall be Belden #8723.
   3. Where plenum cable is required use Belden #88723 with overall natural Flamarrest jacket, UL CMP rated.

B. Power Supply Cable - Provide power cable from Von Duprin power supply to solenoid in the panic bar.
   1. Each power supply cable shall be a 2 conductor, unshielded twisted pair, 18 gauge polyolefin insulated stranded conductors, with overall chrome PVC jacket, UL CMG rated.
   2. Manufacturer shall be Belden #9461

C. Card Reader Communications Cable - Provide communication cable from Card Reader to the control board in the main access control cabinet.
   1. Each card reader cable shall be a 3-pair, individually shielded, 22 gauge, stranded fluorinated ethylene propylene, with (1) 22 gauge stranded tinned copper drain wire and overall chrome FEP jacket, UL CM rated.
   2. Manufacturer shall be Belden #87777 with overall natural Flamarrest jacket, UL CMP rated.

D. Electric Strike Cable – Belden 9461

E. Door Contact Cable – Belden 9461

2.9 ELECTRONIC LOCKING TECHNOLOGY – PROVIDED BY DIVISION 8

A. The security Contractor shall coordinate with the door hardware Contractor on the placement of required electronic locking hardware. The door Contractor will provide and install all electric locking hardware with the associated line voltage power supplies. The security Contractor will provide all necessary wire and cable, low voltage power supplies, terminate all connections, and shall interface this equipment with the integrated security system.

B. Power supplies for delayed egress panic devices and electric latch retraction type locks shall be provided by the door hardware Contractor. This required device has been specified under Division 8.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wiring Method: Install wiring in raceway except within consoles, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

B. Wiring Method: All wiring is to be installed in conduit except as mentioned in part 3.1A above.

C. Install exposed raceways and cables parallel and perpendicular to surfaces or exposed structural members, and follow surface contours. Secure and support cables by straps, staples, or similar fittings designed and installed so as not to damage cables. Secure cable at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150mm) from cabinets, boxes, or fittings.

D. Wiring within Enclosures: Provide adequate length of conductors. Bundle, lace, and train conductors to terminal points with no excess. Provide and use lacing bars in cabinets.

E. Separation of Wires: Run in separate raceways or, if exposed or in same enclosure, provide 12-inch (300 mm) minimum separation between conductors adjacent parallel power and telephone wiring. Provide separation as recommended by equipment manufacturer for other conductors.

F. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes, terminal cabinets, and equipment enclosures. Install terminal cabinets where there are splices, taps, or terminations for eight or more conductors.

G. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks if required.

H. Identification of Conductors and Cables: Retain color-coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with system wiring diagrams. Label stations, controls, and indications using approved consistent nomenclature.

3.2 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other signal impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding except at connection to main building ground bus.

C. Grounding Provisions: Comply with requirements in Division 26 Section "Grounding".

3.3 CONTROLLED DOORS

A. Controlled door consists of a 6" square by 4" deep box with a (1) 1 1/4" EMT continuous from the box to within 18" to 24" from the hallway distribution system. Location of box should be on wall and not be in front of or above the door.

B. If door is equipped with ADA Auto Door Opener install 1/2" EMT to control for interface.

C. New Construction Wooden or Aluminum Doors

1. From the 6" x 6" x 4" box to each door, one (1) 3/4" EMT shall be installed inside the door frame to a box located at the top of the door frame, opposite of the hinged side for the magnetic door switch.

D. With Electrified Panic Hardware or Mortise Type Electrified Lock.

1. From the 6" x 6" x 4" box to each door, one (1) 3/4" EMT shall be installed inside the door frame to a box located inside the door frame, on the hinged side of the door, approximately 6" above the middle hinge for the power transfer.

E. With Electrified Door Strike.

1. From the 6" x 6" x 4" box to each door, one (1) 3/4" EMT shall be installed inside the door frame to a box located inside the door frame, opposite the hinged side of the door, directly across from the latch in the door for an electrified door strike.

3.4 CARD READER DOORS

A. New Construction Wooden or Aluminum Doors
   1. Controlled door consists of a 6" square by 4" deep box with one (1) 1 1/4" EMT continuous from the box to within 18" to 24" from the hallway distribution system. Location of box should be on wall and not be in front of or above the door.
   2. Card Reader door consists of one (1) 3/4" EMT continuous from the card reader back box to the 6" x 6" x 4" junction box above the accessible ceiling which is connected to the Main RS2 Cabinet (if used). Card reader shall be located 42" AFF and located as shown on the drawings.
   3. From the 6" x 6" x 4" junction box to each door, one (1) 3/4" EMT shall be installed inside the door frame to a box located at the top of the door frame, opposite of the hinged side for the door switch.
   4. With Electrified Panic Hardware
      a. One (1) door power supply shall be installed and connected to the junction box by one (1) 3/4" EMT for communication. Electrical connections shall be made in accordance with Division 26 Specifications and drawings.
      b. From the junction box to each door, one (1) 3/4" EMT shall be installed inside the door frame to a box located inside the door frame, on the hinged side of the door, approximately 6" above the middle hinge for the power transfer.
      c. From the reader board box to the magnetic card reader located outside of the door, one (1) 1/2" EMT shall be installed inside the wall to a flush mount box located 42" A.F.F. outside of the door, opposite of the hinged side for the card reader. Refer to construction drawings for card reader locations.
      d. If door is equipped with ADA Auto Door Opener install 1/2" EMT to control for interface if required.
   5. With Mortise Type Electrified Lock.
      a. From the junction box to each door, one (1) 1/2" EMT shall be installed inside the door frame to a box located inside the door frame, on the hinged side of the door, approximately 6" above the middle hinge for the power transfer.
      b. From the reader board box to the card reader located on the unsecured side of the door, one (1) 3/4" EMT shall be installed inside the wall to a flush mount single gang box located 42" A.F.F. outside of the door, opposite of the hinged side for the card reader.
   6. With Electrified Door Strike.
      a. From the junction box to each door, one (1) 1/2" EMT shall be installed inside the door frame to a box located inside the door frame, opposite the hinged side of the door, directly across from the latch in the door for an electrified door strike.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field assembled components and testing and adjusting of system.

B. Test Procedure: Comply with the following:
   1. Schedule tests a minimum of seven days in advance of performance of tests.
   2. Report: Submit a written record of test results.
   3. Operational Test: Perform an operational system test to verify compliance of system with these Specifications.

C. Retesting: Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense. Verify by the system test that the total system meets these Specifications and complies with applicable standards. Report results in writing.

D. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

E. System Testing:
   1. All Controlled doors shall be tested for proper operation as follows:
      a. With door(s) closed and locked, verify all switches are closed, zero resistance, and multiplexer board is indicating inactive status, green LED (on) for the particular point.
      b. With door(s) closed and locked, push each panic bar or handle without opening door to verify LX switches open, infinite resistance, and board is indicating active status, green LED (off) for the particular point. Release bar or handle to verify status changes back to inactive and LX switch(s) close, zero resistance.

c. With door(s) closed and locked, open each door individually to verify door switches open, infinite resistance, and board is indicating active status, green LED (off) for particular point. Close door to verify status changes back to inactive.
d. Contact Owner's representative to verify computer control of door location.

2. All Card Reader doors shall be tested for proper operation as follows:
a. With door(s) closed and locked, verify all switches are closed, zero resistance.
b. With door(s) closed and locked, push each panic bar or handle without opening door to verify LX switches are opening, infinite resistance. Release bar or handle to verify LX changes back to a closed state, zero resistance.
c. Contact Owner's representative to verify computer control door location and confirm unit is online.
d. Swipe valid card through read-head to verify door unlocks, opens, and closes.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel and staff.
1. Schedule training with Owner with at least seven days' advance notice.
2. Train Owner's maintenance personnel on procedures and schedules related to starting and stopping, troubleshooting, servicing, and preventive maintenance. Provide a minimum of two (2) hours of training.

END OF SECTION

DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Nonsystem smoke detectors.
5. Heat detectors.
6. Notification appliances.
7. Firefighters' two-way telephone communication service.
8. Magnetic door holders.
9. Remote annunciator.
10. Addressable interface device.
11. Digital alarm communicator transmitter.
12. Radio alarm transmitter.
13. System printer.
14. City of Chicago “OEMC’ tie box.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. NICET: National Institute for Certification in Engineering Technologies.

1.4 SYSTEM DESCRIPTION

A. Noncoded, UL-certified addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

B. Noncoded addressable system, with automatic sensitivity control of certain smoke detectors and multiplexed signal transmission, dedicated to fire-alarm service only.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.6 SUBMITTALS

A. General Submittal Requirements:
1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:
a. Trained and certified by manufacturer in fire-alarm system design.
b. NICET-certified fire-alarm technician, Level III minimum.
c. Licensed or certified by authorities having jurisdiction.

B. Product Data: For each type of product indicated.

C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.
1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
2. Include voltage drop calculations for notification appliance circuits.
3. Include battery-size calculations.
4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show

critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.

6. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
7. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

D. Delegated-Design Submittal: For smoke and heat detectors indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Drawings showing the location of each smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the detector.
   2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.

E. Qualification Data: For qualified Installer.

F. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Field quality-control reports.

H. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
   2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
   3. Record copy of site-specific software.
   4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
      a. Frequency of testing of installed components.
      b. Frequency of inspection of installed components.
      c. Requirements and recommendations related to results of maintenance.
      d. Manufacturer's user training manuals.
   5. Manufacturer's required maintenance related to system warranty requirements.
   6. Abbreviated operating instructions for mounting at fire-alarm control unit.
   7. Copy of NFPA 25.

I. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On magnetic media or compact disk, complete with data files.
   3. Device address list.
   4. Printout of software application and graphic screens.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire- alarm Level III technician.

C. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FMG-approved alarm company.

F. Comply with City of Chicago Building Code.

1.8 PROJECT CONDITIONS

A. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
1. Notify Architect no fewer than seven days in advance of proposed interruption of fire-alarm service.
2. Do not proceed with interruption of fire-alarm service without Architect's written permission.

1.9 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.10 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two years.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.11 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.
3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than 1 unit of each type.
4. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but no fewer than 1 unit of each type.
5. Keys and Tools:One extra set for access to locked and tamperproofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Siemens Building Technologies, Inc.; Fire Safety Division.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:
1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Verified automatic alarm operation of smoke detectors.
6. Automatic sprinkler system water flow.

7. Heat detectors in elevator shaft and pit.
8. Fire-extinguishing system operation.
9. Fire standpipe system.

B. Fire-alarm signal shall initiate the following actions:
1. Continuously operate alarm notification appliances.
2. Identify alarm at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.
7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Activate smoke-control system (smoke management) at firefighter smoke-control system panel.
9. Activate stairwell and elevator-shaft pressurization systems.
10. Close smoke dampers in air ducts of designated air-conditioning duct systems.
11. Recall elevators to primary or alternate recall floors.
12. Activate emergency lighting control.
13. Activate emergency shutoffs for gas and fuel supplies.
14. Shut down Air Handling Units (AHU). These AHU's shall be restarted manually upon removal of the fire alarm.
15. Activate City of Chicago "OEMC" call
16. Record events in the system memory.
17. Record events by the system printer.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:
1. Valve supervisory switch.
2. Low-air-pressure switch of a dry-pipe sprinkler system.
3. Elevator shunt-trip supervision.

D. System trouble signal initiation shall be by one or more of the following devices and actions:
1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal- initiating devices.
3. Loss of primary power at fire-alarm control unit.
4. Ground or a single break in fire-alarm control unit internal circuits.
5. Abnormal ac voltage at fire-alarm control unit.
6. Break in standby battery circuitry.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm control unit or annunciator.
9. Fire-pump power failure, including a dead-phase or phase-reversal condition.
10. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system.

E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators. Record the event on system printer.

2.3 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:
1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
b. Include a real-time clock for time annotation of events on the event recorder and printer.
2. Addressable initiation devices that communicate device identity and status.
a. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit.
b. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.
3. Addressable control circuits for operation of mechanical equipment.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, 3 line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

C. Circuits:
1. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.
   a. Initiating Device Circuits: Style D.
   b. Notification Appliance Circuits: Style Z.
   c. Signaling Line Circuits: Style 2.
   d. Install no more than 50 addressable devices on each signaling line circuit.
2. Serial Interfaces: Two RS-232 ports for printers.

D. Stairwell Pressurization: Provide an output signal using an addressable relay to start the stairwell pressurization system. Signal shall remain on until alarm conditions are cleared and fire-alarm system is reset. Signal shall not stop in response to alarm acknowledge or signal silence commands.
1. Pressurization starts when any alarm is received at fire-alarm control unit.
2. Alarm signals from smoke detectors at pressurization air supplies have a higher priority than other alarm signals that start the system.

E. Smoke-Alarm Verification:
1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an NRTL-listed and -approved "alarm-verification" sequence at fire- alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

F. Notification Appliance Circuit: Operation shall sound in a <Insert pattern>.

G. Elevator Recall:
1. Smoke detectors at the following locations shall initiate automatic elevator recall. Alarm-initiating devices, except those listed, shall not start elevator recall.
   a. Elevator lobby detectors except the lobby detector on the designated floor.
   b. Smoke detector in elevator machine room.
   c. Smoke detectors in elevator hoistway.
2. Elevator lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.
   a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

H. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be connected to fire-alarm system.

I. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

J. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

K. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as a special module that is part of fire-alarm control unit.
1. Indicated number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711 and be listed by an NRTL.
   a. Allow the application of and evacuation signal to indicated number of zones and, at same time, allow voice paging to the other zones selectively or in any combination.
   b. Programmable tone and message sequence selection.

c. Standard digitally recorded messages for "Evacuation" and "All Clear."
d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification appliance circuits of fire-alarm control unit.

2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.

L. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

M. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals shall be powered by 24-V dc source.
1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

N. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
1. Batteries: Sealed lead calcium.

O. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
1. Single-action mechanism, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Double-action mechanism requiring two actions to initiate an alarm, breaking- glass or plastic-rod and pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
3. Station Reset: Key- or wrench-operated switch.
4. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
5. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:
1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be four-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.

7. Remote Control: Unless otherwise indicated, detectors shall be analog- addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire- alarm control unit.
   a. Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15 or 20 deg F per minute.
   b. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F.
   c. Provide multiple levels of detection sensitivity for each sensor.

B. Photoelectric Smoke Detectors:
   1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
   2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      a. Primary status.
      b. Device type.
      c. Present average value.
      d. Present sensitivity selected.
      e. Sensor range (normal, dirty, etc.).

C. Ionization Smoke Detector:
   1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
   2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      a. Primary status.
      b. Device type.
      c. Present average value.
      d. Present sensitivity selected.
      e. Sensor range (normal, dirty, etc.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
   1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
   2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      a. Primary status.
      b. Device type.
      c. Present average value.
      d. Present sensitivity selected.
      e. Sensor range (normal, dirty, etc.).
   3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
   4. Each sensor shall have multiple levels of detection sensitivity.
   5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
   6. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.6 NONSYSTEM SMOKE DETECTORS

A. Single-Station Smoke Detectors:
   1. Comply with UL 217; suitable for NFPA 101, residential occupancies; operating at 120-V ac[with 9-V dc battery as the secondary power source. Provide with "low" or "missing" battery chirping-sound device].
   2. Auxiliary Relays: One Form A and one Form C, both rated at 0.5 A.
   3. Audible Notification Appliance: Piezoelectric sounder rated at 90 dBA at 10 feet according to UL 464.
   4. Visible Notification Appliance: 177-cd strobe.
   5. Heat sensor, 135 deg F [combination rate-of-rise and]fixed temperature.
   6. Test Switch: Push to test; simulates smoke at rated obscuration.
   7. Tandem Connection: Allow tandem connection of number of indicated detectors; alarm on one detector shall actuate notification on all connected detectors.

8. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
9. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
10. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.

B. Single-Station Duct Smoke Detectors:
1. Comply with UL 268A; operating at 120-V ac.
2. Sensor: LED or infrared light source with matching silicon-cell receiver.
a. Detector Sensitivity: Smoke obscuration between 2.5 and 3.5 percent/foot when tested according to UL 268A.
3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to air duct. Provide terminals in the fixed base for connection to building wiring.
a. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
4. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
5. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.7 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg For a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F.
1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

D. Continuous Linear Heat-Detector System:
1. Detector Cable: Rated detection temperature 155 deg F. NRTL listed for "regular" service and a standard environment. Cable includes two steel actuator wires twisted together with spring pressure, wrapped with protective tape, and finished with PVC outer sheath. Each actuator wire is insulated with heat- sensitive material that reacts with heat to allow the cable twist pressure to short-circuit wires at the location of elevated temperature.
2. Control Unit: Two-zone or multizone unit as indicated. Provide same system power supply, supervision, and alarm features as specified for fire-alarm control unit.
3. Signals to Fire-Alarm Control Unit: Any type of local system trouble shall be reported to fire-alarm control unit as a composite "trouble" signal. Alarms on each detection zone shall be individually reported to central fire-alarm control unit as separately identified zones.
4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.8 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling line circuit, equipped for mounting as indicated and with screw terminals for system connections.

B. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.
1. Combination Devices: Factory-integrated audible and visible devices in a single- mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.

C. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.

D. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.

E. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

F. Visible Notification Appliances: Xenon strode lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- high letters on the lens.
1. Rated Light Output:
   a. 110 cd.
   b. 15/30/75/110 cd, selectable in the field.
2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, red.

G. Voice/Tone Notification Appliances:
1. Appliances shall comply with UL 1480 and shall be listed and labeled by an NRTL.
2. High-Range Units: Rated 2 to 15 W.
3. Low-Range Units: Rated 1 to 2 W.
4. Mounting: Flush.
5. Matching Transformers: Tap range matched to acoustical environment of speaker location.

2.9 FIREFIGHTERS' TWO-WAY TELEPHONE COMMUNICATION SERVICE

A. Dedicated, two-way, supervised, telephone voice communication links between fire- alarm control unit, the fire command center, and remote firefighters' telephone stations. Supervised telephone lines shall be connected to talk circuits by controls in a control module. Provide the following:
1. Common-talk type for firefighter use only.
2. Selective-talk type for use by firefighters and fire wardens.
3. Controls to disconnect phones from talk circuits if too many phones are in use simultaneously.
4. Audible Pulse and Tone Generator, and High-Intensity Lamp: When a remote telephone is activated, it causes audible signal to sound and high-intensity lamp to flash.
5. Selector panel controls shall provide for simultaneous operation of up to six telephones in selected zones. Indicate ground faults and open or shorted telephone lines on the panel front by individual LEDs.
6. Display: Graphic and Liquid-crystal digital to indicate location of caller.
7. Remote Telephone Cabinet: Flush- or surface-mounted cabinet as indicated, factory-standard red finish, with handset.
   a. Install one-piece handset to cabinet with vandal-resistant armored cord.
      Silk-screened or engraved label on cabinet door, designating "Fire Emergency Phone."
   b. With "break-glass" type door access lock.
8. Remote Telephone Jack Stations: Single-gang, stainless-steel-plate mounted plug, engraved "Fire Emergency Phone."
9. Handsets: push-to-talk-type sets with noise-canceling microphone stored in a cabinet adjacent to fire-alarm control unit.

2.10 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
1. Electromagnet: Requires no more than 3 W to develop 25-lbf holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.11 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.12 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.

B. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall.

2.13 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture [one] [two] telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on[either] line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:
1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:
1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply or loss of power.
5. Low battery.
6. Abnormal test signal.
7. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.14 SYSTEM PRINTER

A. Printer shall be listed and labeled by an NRTL as an integral part of fire-alarm system.

2.15 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
1. Factory fabricated and furnished by manufacturer of device.
2. Finish: Paint of color to match the protected device.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. Equipment Mounting: Install fire-alarm control unit on concrete base with tops of cabinets not more than 72 inches above the finished floor. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."
1. Install seismic bracing. Comply with requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Equipment Mounting: Install fire-alarm control unit on finished floor with tops of cabinets not more than 72 inches above the finished floor.
1. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Install wall-mounted equipment, with tops of cabinets not more than 72 inches above the finished floor.
1. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
1. Connect new equipment to existing control panel in existing part of the building.
2. Connect new equipment to existing monitoring equipment at the supervising station.
3. Expand, modify, and supplement existing control and monitoring equipment as necessary to extend existing control and monitoring functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

F. Smoke- or Heat-Detector Spacing:
1. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.
2. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A or Appendix B in NFPA 72.
5. HVAC: Locate detectors not closer than 3 feet from air-supply diffuser or return- air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.

G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

H. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

I. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

J. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

K. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

L. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling.

M. Device Location-Indicating Lights: Locate in public space near the device they monitor.

N. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than 72 inches above the finished floor.

O. Annunciator: Install with top of panel not more than 72 inches above the finished floor.

3.2 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
1. Alarm-initiating connection to smoke-control system (smoke management) at firefighter smoke-control system panel.
2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
3. Smoke dampers in air ducts of designated air-conditioning duct systems.
4. Alarm-initiating connection to elevator recall system and components.
5. Alarm-initiating connection to activate emergency lighting control.
6. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
7. Supervisory connections at valve supervisory switches.
8. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
9. Supervisory connections at elevator shunt trip breaker.
10. Supervisory connections at fire-pump power failure including a dead-phase or phase reversal condition.
11. Supervisory connections at fire-pump engine control panel.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.4 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

3.5 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Architect and authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:
1. Visual Inspection: Conduct visual inspection prior to testing.
a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

I. Annual Test and Inspection: One year after date of Substantial Completion, test fire- alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION

SOILS FOR EARTHWORK

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Subsoil materials.
   2. Topsoil materials.

B. Related Sections:
   1. Section 31 05 16 - Aggregates for Earthwork.
   2. Section 31 23 17 - Trenching.

1.2 REFERENCES

A. ASTM International:
   1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
   2. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).
   3. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Materials Source: Submit name of imported materials source.

1.4 SUSTAINABLE DESIGN SUBMITTALS

A. Section 01 81 13 - Sustainable Design Requirements: Requirements for sustainable design submittals.

B. Manufacturer's Certificate: Certify products meet or exceed specified sustainable design requirements.
   1. Materials Resources Certificates:
      a. Certify source for regional materials and distance from Project site.

C. Product Cost Data: Submit cost of products to verify compliance with Project sustainable design requirements. Exclude cost of labor and equipment to install products.
   1. Provide cost data for the following products:
      a. Regional products.

1.5 QUALITY ASSURANCE

A. Furnish each topsoil material from single source throughout the Work.

B. Perform Work in accordance with INDOT standards.

PART 2 PRODUCTS

2.1 SUSTAINABILITY CHARACTERISTICS

A. Section 01 81 13 - Sustainable Design Requirements: Requirements for sustainable design compliance.

B. Materials and Resources Characteristics:
   1. Regional Materials: Furnish materials extracted, processed, and manufactured within 500 miles of Project site.

2.2 SUBSOIL MATERIALS

A. Subsoil Type S1:
   1. Excavated and re-used material.
   2. Graded.
   3. Free of lumps larger than 3 inches, rocks larger than 2 inches, and debris.

2.3 TOPSOIL MATERIALS

A. Topsoil Type S2:

1. Excavated and reused material.
2. Graded.
3. Free of roots, rocks larger than 1/2 inch, subsoil, debris, large weeds and foreign matter.

PART 3 EXECUTION

3.1 EXCAVATION

A. Excavate subsoil and topsoil from areas designated. Strip topsoil to full depth of topsoil in designated areas.
B. Stockpile excavated material meeting requirements for subsoil materials and topsoil materials.
C. Remove excavated materials not meeting requirements for subsoil materials and topsoil materials from site.

3.2 STOCKPILING

A. Stockpile materials on site at locations designated by Architect/Engineer.
B. Stockpile in sufficient quantities to meet Project schedule and requirements.
C. Separate differing materials with dividers or stockpile apart to prevent mixing.
D. Prevent intermixing of soil types or contamination.
E. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

3.3 STOCKPILE CLEANUP

A. Leave unused materials in neat, compact stockpile.
B. When borrow area is indicated, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

END OF SECTION

AGGREGATES FOR EARTHWORK

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Coarse aggregate materials.
   2. Fine aggregate materials.

B. Related Sections:
   1. Section 31 05 13 - Soils for Earthwork: Fill and grading materials.
   2. Section 31 23 17 - Trenching.
   3. Section 32 11 23 - Aggregate Base Courses.
   4. Section 33 11 16 - Site Water Utility Distribution Piping.
   5. Section 33 31 00 - Sanitary Utility Sewerage Piping.
   6. Section 33 41 00 - Storm Utility Drainage Piping.

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials:
   1. AASHTO M147 - Standard Specification for Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses.

B. ASTM International:
   1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   2. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
   3. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
   4. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

1.3 SUSTAINABLE DESIGN SUBMITTALS

A. Section 01 81 13 - Sustainable Design Requirements: Requirements for sustainable design submittals.

B. Manufacturer's Certificate: Certify products meet or exceed specified sustainable design requirements.
   1. Materials Resources Certificates:
      a. Certify source for regional materials and distance from Project site.
      b. Certify recycled material content for recycled content products.

C. Product Cost Data: Submit cost of products to verify compliance with Project sustainable design requirements. Exclude cost of labor and equipment to install products.
   1. Provide cost data for the following products:
      a. Regional products.
      b. Products with recycled material content.

1.4 QUALITY ASSURANCE

A. Furnish each aggregate material from single source throughout the Work.

B. Perform Work in accordance with INDOT standards.

PART 2 PRODUCTS

2.1 SUSTAINABILITY CHARACTERISTICS

A. Section 01 81 13 - Sustainable Design Requirements: Requirements for sustainable design compliance.

B. Materials and Resources Characteristics:
   1. Recycled Content Materials: Furnish materials with maximum available recycled content.

2. Regional Materials: Furnish materials extracted, processed, and manufactured within 500 miles of Project site.

2.2 COARSE AGGREGATE MATERIALS

A. Coarse Aggregate Types as shown on Drawings: Conform to INDOT Standards.

2.3 FINE AGGREGATE MATERIALS

A. Fine Aggregate Types as shown on Drawings: Conform to INDOT standards.

PART 3 EXECUTION

3.1 STOCKPILING

A. Stockpile materials on site at locations designated by Architect/Engineer.

B. Stockpile in sufficient quantities to meet Project schedule and requirements.

C. Separate different aggregate materials with dividers or stockpile individually to prevent mixing.

D. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

3.2 STOCKPILE CLEANUP

A. Remove stockpile, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

END OF SECTION

SITE CLEARING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Removing designated paving and curbs.
   2. Removing designated trees, shrubs, and other plant life.
   3. Removing abandoned utilities.

1.2 SUSTAINABLE DESIGN SUBMITTALS

A. Requirements for sustainable design submittals.

B. Manufacturer's Certificate: Certify products meet or exceed specified sustainable design requirements.
   1. Materials Resources Certificates:
      a. Certify source for regional materials and distance from Project site.

C. Product Cost Data: Submit cost of products to verify compliance with Project sustainable design requirements. Exclude cost of labor and equipment to install products.
   1. Provide cost data for the following products:
      a. Regional products.

1.3 QUALITY ASSURANCE

A. Conform to applicable code for environmental requirements and disposal of debris.

B. Perform Work in accordance with INDOT standards.

PART 2 PRODUCTS

2.1 SUSTAINABILITY CHARACTERISTICS

A. Section 01 81 13 - Sustainable Design Requirements: Requirements for sustainable design.

B. Materials and Resources Characteristics:
   1. Regional Materials: Furnish materials extracted, processed, and manufactured within 500 miles of Project site.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify existing plant life designated to remain is tagged or identified.

3.2 PREPARATION

A. Call Local Utility Line Information service (811) not less than two working days before performing Work.
   1. Request underground utilities to be located and marked within and surrounding construction areas.

3.3 PROTECTION

A. Locate, identify, and protect utilities indicated to remain, from damage.

B. Protect trees, plant growth, and features designated to remain, as final landscaping.

C. Protect bench marks, survey control points, and existing structures from damage or displacement.

3.4 CLEARING

A. Clear areas required for access to site and execution of Work as required.

B. Remove trees and shrubs within marked areas and as indicated. Remove stumps and root system to depth of 36 inches.

3.5 REMOVAL

A. Remove debris, rock, and extracted plant life from site.

B. Remove paving and curbs as indicated on Drawings. Neatly saw cut edges at right angle to surface.

C. Remove abandoned utilities. Indicated removal termination point for underground utilities on Record Documents.

D. Continuously clean-up and remove waste materials from site. Do not allow materials to accumulate on site.

E. Do not burn or bury materials on site. Leave site in clean condition.

3.6 TOPSOIL EXCAVATION

A. Excavate topsoil from areas as shown without mixing with foreign materials for use in finish grading.

B. Do not excavate wet topsoil.

C. Stockpile in area designated on site and protect from erosion.

D. Do not remove topsoil from site.

END OF SECTION

EXCAVATION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Excavating for building foundations.
   2. Excavating for paving, roads, and parking areas.
   3. Excavating for slabs-on-grade.
   4. Excavating for site structures.

B. Related Sections:
   1. Section 31 05 13 - Soils for Earthwork: Stockpiling excavated materials.
   2. Section 31 05 16 - Aggregates for Earthwork: Stockpiling excavated materials.
   3. Section 31 23 17 - Trenching: Excavating for utility trenches.
   4. Section 31 23 18 - Rock Removal: Removal of rock during excavating.
   5. Section 33 11 16 - Site Water Utility Distribution Piping.

1.2 REFERENCES

A. Local utility standards when working within 24 inches of utility lines.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Excavation Protection Plan: Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with INDOT standards

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 PREPARATION

A. Call Local Utility Line Information service at 811 not less than two working days before performing Work.
   1. Request underground utilities to be located and marked within and surrounding construction areas.
   2. Notify Owner and Designer not less than two days before starting work.

B. Identify required lines, levels, contours, and datum.

C. Protect utilities indicated to remain from damage.

D. Protect plant life, lawns, and other features remaining as portion of final landscaping.

E. Protect bench marks, survey control points, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

3.2 EXCAVATION

A. Underpin adjacent structures which may be damaged by excavation work.

B. Excavate subsoil to accommodate building foundations, slabs-on-grade, paving and site structures.

C. Compact disturbed load bearing soil in direct contact with foundations to original bearing capacity.

D. Do not interfere with 45 degree bearing splay of foundations.

E. Grade top perimeter of excavation to prevent surface water from draining into excavation. Trim excavation. Remove loose matter.

F. Remove lumped subsoil, boulders, and rock up to 1/3 cu yd measured by volume.

G. Notify Architect/Engineer of unexpected subsurface conditions.

H. Correct areas over excavated as directed by Architect/Engineer.

I. Remove excess and unsuitable material from site.
J. Stockpile excavated material in area designated on site in accordance with Sections 31 05 13.
K. Repair or replace items indicated to remain damaged by excavation.

3.3 FIELD QUALITY CONTROL

A. Section 01 70 00 - Execution and Closeout Requirements: Field inspecting and testing.
B. Request visual inspection of bearing surfaces by Architect/Engineer before installing subsequent work.

3.4 PROTECTION

A. Prevent displacement or loose soil from falling into excavation; maintain soil stability.
B. Protect bottom of excavations and soil adjacent to and beneath foundation from freezing.
C. Protect structures, utilities and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth operations.

END OF SECTION

ROCK REMOVAL

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Removing identified and discovered rock during excavation.
   2. Expansive tools to assist rock removal.

B. Related Sections:
   1. Section 31 22 13 - Rough Grading.
   2. Section 31 23 16 - Excavation: Building excavation.
   3. Section 31 23 17 - Trenching: Trenching and backfilling for utilities.
   4. Section 31 23 23 - Fill: Backfill materials.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Rock Removal:
   1. Basis of Measurement: By cubic yard measured before removal.
   2. Basis of Payment: Includes preparation of rock for removal, removal from position, loading and removing from site. For over excavation, payment will not be made for over excavated work nor for replacement materials.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Submittal procedures.

B. Shop Drawings: Indicate intended rock removal method.

1.4 SCHEDULING

A. Section 01 30 00 - Administrative Requirements: Coordination and project conditions.

B. Schedule Work to avoid disruption to occupied buildings nearby.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Coordination and project conditions.

B. Verify site conditions and note subsurface irregularities affecting Work of this section.

3.2 PREPARATION

A. Identify required lines, levels, contours, and datum.

3.3 ROCK REMOVAL

A. Cut away rock at bottom of excavation to form level bearing.

B. Remove shaled layers to provide sound and unshattered base for footings and foundations.

C. In utility trenches, excavate to 8 inches below invert elevation of pipe and 24 inches wider than pipe diameter.

D. Remove excavated materials from site.

E. Correct unauthorized rock removal as directed by Architect/Engineer.

3.4 FIELD QUALITY CONTROL

A. Section 01 70 00 - Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.

B. Request visual inspection of foundation bearing surfaces by Architect/Engineer before installing subsequent work.

END OF SECTION

ASPHALT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Cold milling of existing hot-mix asphalt pavement.
   2. Hot-mix asphalt patching.
   3. Hot-mix asphalt paving.
   4. Pavement-marking paint.

B. Related Sections:
   1. Division 02 Section "Structure Demolition" for demolition, removal, and recycling of existing asphalt pavements, and for geotextiles that are not embedded within courses of asphalt paving.
   2. Division 31 Section "Earth Moving" for aggregate subbase and base courses and for aggregate pavement shoulders.
   3. Division 32 Sections for other paving installed as part of crosswalks in asphalt pavement areas.
   4. Division 32 Section "Concrete Paving Joint Sealants" for joint sealants and fillers at paving terminations.
   5. Division 32 Section "Unit Paving" for bituminous setting bed for pavers.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
   1. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.

B. Shop Drawings: Indicate pavement markings, lane separations, and defined parking spaces. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

C. Qualification Data: For qualified manufacturer.

D. Material Certificates: For each paving material, from manufacturer.

E. Material Test Reports: For each paving material.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located.

B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of the current Standard Specifications of Indiana Department of Transportation for asphalt paving work.
   1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.

B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
   1. Tack Coat: Minimum surface temperature of 60 deg F.
   2. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
   3. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.

B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for oil-based materials and not exceeding 95 deg F.

PART 2 - PRODUCTS

2.1 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations.

B. Coarse Aggregate: Class A or B, sound, angular crushed stone or crushed gravel conforming to the current Standard Specifications of the Indiana Department of Transportation.

C. Fine Aggregate: Sharp-edged natural sand conforming to the current Standard Specifications of the Indiana Department of Transportation.

2.2 ASPHALT MATERIALS

A. Asphalt Cement: Petroleum asphalt cement conforming to the current Standard Specifications of the Indiana Department of Transportation.

B. Tack Coat: Rapid cure liquid asphalt or asphalt emulsion conforming to the current Standard Specifications of the Indiana Department of Transportation.

C. Water: Potable.

2.3 AUXILIARY MATERIALS

A. Pavement-Marking Paint: MPI #32 Alkyd Traffic Marking Paint.
1. Color: As indicated.

2.4 MIXES

A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes conforming to the current Standard Specifications of the Indiana Department of Transportation.
1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Provide mixes complying with composition, grading, and tolerance requirements in the current Standard Specifications of the Indiana Department of Transportation for the following nominal, maximum aggregate sizes:
a. Base Course: 1 inch.
b. Surface Course: 1/2 inch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

C. Proceed with paving only after unsatisfactory conditions have been corrected.

D. Verify that utilities, traffic loop detectors, and other items requiring a cut and installation beneath the asphalt surface have been completed and that asphalt surface has been repaired flush with adjacent asphalt prior to beginning installation of imprinted asphalt.

3.2 COLD MILLING

A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.
1. Mill to a uniform finished surface free of excessive gouges, grooves, and ridges.
2. Control rate of milling to prevent tearing of existing asphalt course.
3. Repair or replace curbs, manholes, and other construction damaged during cold milling.

4. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
5. Transport milled hot-mix asphalt to asphalt recycling facility.
6. Keep milled pavement surface free of loose material and dust.

3.3 PATCHING

A. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of 0.05 to 0.15 gal./sq. yd.
1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

C. Patching: Fill excavated pavements with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

3.4 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.
1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.5 HOT-MIX ASPHALT PLACING

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
2. Place hot-mix asphalt surface course in single lift.
3. Spread mix at minimum temperature of 250 deg F.
4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete a section of asphalt base course before placing asphalt surface course.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.6 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.
1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
3. Offset transverse joints, in successive courses, a minimum of 24 inches.
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."
5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.7 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.
   1. Complete compaction before mix temperature cools to 185 deg F.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
   1. Average Density: 96 percent of reference laboratory density according to ASTM D 6927, but not less than 94 percent nor greater than 100 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.8 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
   1. Base Course: Plus or minus 1/2 inch.
   2. Surface Course: Plus 1/4 inch, no minus.

B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
   1. Base Course: 1/4 inch.
   2. Surface Course: 1/8 inch.
   3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

3.9 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

B. Allow paving to age for 30 days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.

C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

D. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979.
   1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.

E. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.11 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.
   1. Do not allow milled materials to accumulate on-site.

END OF SECTION

CONCRETE PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Curbs and gutters.
   2. Walks.

B. Related Sections:
   1. Section 03 30 00 "Cast-in-Place Concrete" for general building applications of concrete.
   2. Section 32 13 73 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt paving or adjacent construction.

1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. LEED Submittals:
   1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.
   2. Design Mixtures for Credit ID 1: For each concrete mixture containing fly ash as a replacement for portland cement or other portland cement replacements. For each design mixture submitted, include an equivalent concrete mixture that does not contain portland cement replacements, to determine amount of portland cement replaced.

C. Shop Drawings: Indicate pavement markings, lane separations, and defined parking spaces. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

D. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color selection.

E. Other Action Submittals:
   1. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified ready-mix concrete manufacturer and testing agency.

B. Material Certificates: For the following, from manufacturer:
   1. Cementitious materials.
   2. Steel reinforcement and reinforcement accessories.
   3. Fiber reinforcement.
   4. Admixtures.
   5. Curing compounds.
   6. Applied finish materials.
   7. Bonding agent or epoxy adhesive.
   8. Joint fillers.

C. Material Test Reports: For each of the following:
   1. Aggregates. Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Detectable Warning Installer Qualifications: An employer of workers trained and approved by manufacturer of stamped concrete paving systems.

B. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
   1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

C. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
   1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

D. Concrete Testing Service: Engage a qualified testing agency to perform material evaluation tests and to design concrete mixtures.

E. ACI Publications: Comply with ACI 301 unless otherwise indicated.

F. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Build mockups of full-thickness sections of concrete paving to demonstrate typical joints; surface finish, texture, and color; curing; and standard of workmanship.
   2. Build mockups of concrete paving in the location and of the size indicated or, if not indicated, build mockups where directed by Architect and not less than 96 inches by 96 inches. Include full-size detectable warning.
   3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
   4. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

G. Preinstallation Conference: Conduct conference at Project site.
   1. Review methods and procedures related to concrete paving, including but not limited to, the following:
      a. Concrete mixture design.
      b. Quality control of concrete materials and concrete paving construction practices.
      c. Finishes and joints.
   2. Require representatives of each entity directly concerned with concrete paving to attend, including the following:
      a. Contractor's superintendent.
      b. Independent testing agency responsible for concrete design mixtures.
      c. Ready-mix concrete manufacturer.
      d. Concrete paving subcontractor.

1.7 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 - PRODUCTS

2.1 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
   1. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less. Do not use notched and bent forms.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.2 STEEL REINFORCEMENT

A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Epoxy-Coated, Joint Dowel Bars: ASTM A 775/A 775M; with ASTM A 615/A 615M, Grade 60, plain-steel bars.

2.3 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source throughout Project:
   1. Portland Cement: ASTM C 150, portland cement Type I.[Supplement with the following:]
      a. Fly Ash: ASTM C 618, Class C or Class F.
      b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

B. Normal-Weight Aggregates: ASTM C 33, Class 4S, uniformly graded. Provide aggregates from a single source[with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials].
   1. Maximum Coarse-Aggregate Size: 3/4 inch nominal.
   2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Water: Potable and complying with ASTM C 94/C 94M.

D. Air-Entraining Admixture: ASTM C 260.

E. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
   1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
   2. Retarding Admixture: ASTM C 494/C 494M, Type B.
   3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
   4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
   5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
   6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

2.4 FIBER REINFORCEMENT

A. Synthetic Fiber: Monofilament or fibrillated polypropylene fibers engineered and designed for use in concrete paving, complying with ASTM C 1116/C 1116M, Type III, 1/2 to 1-1/2 inches long.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Monofilament Fibers:
         1) Axim Italcementi Group, Inc.; FIBRASOL II P.
         2) Euclid Chemical Company (The), an RPM company; Fiberstrand 100, Fiberstrand 150.
         3) FORTA Corporation; FORTA ECONO-MONO or FORTA Mighty-Mono.
         4) Grace, W. R. & Co. - Conn.; Grace MicroFiber.
         5) Metalcrete Industries; Polystrand 1000.
         6) QC Construction Products; QC FIBERS.
      b. Fibrillated Fibers:
         1) Axim Italcementi Group, Inc.; FIBRASOL F.
         2) Euclid Chemical Company (The), an RPM company; Fiberstrand F.
         3) FORTA Corporation; FORTA Econo-Net or FORTA Super-Net.
         4) Grace, W. R. & Co. - Conn.; Grace Fibers.
         5) Propex Concrete Systems Corp.; Fibermesh 300.

2.5 CURING MATERIALS

A. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

B. Water: Potable.

C. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Axim Italcementi Group, Inc.; Caltexol CIMFILM.
      b. BASF Construction Chemicals, LLC; Confilm.
      c. ChemMasters; Spray-Film.
      d. Conspec by Dayton Superior; Aquafilm.

e. Dayton Superior Corporation; Sure Film (J-74).
f. Edoco by Dayton Superior; BurkeFilm.
g. Euclid Chemical Company (The), an RPM company; Eucobar.
h. Kaufman Products, Inc.; VaporAid.
i. Lambert Corporation; LAMBCO Skin.
j. L&M Construction Chemicals, Inc.; E-CON.
k. Meadows, W. R., Inc.; EVAPRE.
l. Metalcrete Industries; Waterhold.
m. Nox-Crete Products Group; MONOFILM.
n. Sika Corporation, Inc.; SikaFilm.
o. SpecChem, LLC; Spec Film.
p. Symons by Dayton Superior; Finishing Aid.
q. TK Products, Division of Sierra Corporation; TK-2120 TRI-FILM.
r. Unitex; PRO-FILM.
s. Vexcon Chemicals Inc.; Certi-Vex EnvioAssist.

D. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Anti-Hydro International, Inc.; A-H Curing Compound #2 DR WB.
b. ChemMasters; Safe-Cure Clear.
c. Dayton Superior Corporation; Day-Chem Rez Cure (J-11-W).
d. Euclid Chemical Company (The), an RPM company; Kurez W VOX.
e. Kaufman Products, Inc.; Thinfilm 420.
f. Lambert Corporation; AQUA KURE - CLEAR.
g. L&M Construction Chemicals, Inc.; L&M CURE R.
h. Meadows, W. R., Inc.; 1100-CLEAR SERIES.
i. Nox-Crete Products Group; Resin Cure E.
j. SpecChem, LLC; PaveCure Rez.
k. Symons by Dayton Superior; Resi-Chem Clear.
l. Tamms Industries, Inc., Euclid Chemical Company (The); TAMMSCURE WB 30C.
m. Vexcon Chemicals Inc.; Certi-Vex Enviocure 100.

2.6 RELATED MATERIALS

A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber in preformed strips.

B. Epoxy Bonding Adhesive: ASTM C 881/C 881M, two-component epoxy resin capable of humid curing and bonding to damp surfaces; of class suitable for application temperature, of grade complying with requirements, and of the following types:

2.7 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.
1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
2. When automatic machine placement is used, determine design mixtures and obtain laboratory test results that meet or exceed requirements.

B. Proportion mixtures to provide normal-weight concrete with the following properties:
1. Compressive Strength (28 Days): 4000 psi.
2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45.
3. Slump Limit: 4 inches, plus or minus 1 inch.

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
1. Air Content: 6 percent plus or minus 1.5 percent for 3/4-inch nominal maximum aggregate size.

D. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
1. Use admixtures in concrete as required for placement and workability.

2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

F. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
1. Fly Ash or Pozzolan: 25 percent.
2. Ground Granulated Blast-Furnace Slag: 50 percent.
3. Combined Fly Ash or Pozzolan, and Ground Granulated Blast-Furnace Slag: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

G. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.5 lb/cu. yd.

2.8 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.
1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.
1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph.
2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Section 31 23 16 "Excavation."

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
2. Provide tie bars at sides of paving strips where indicated.
3. Butt Joints: Use epoxy bonding adhesive at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

4. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
5. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.
1. Locate expansion joints at intervals of 50 feet unless otherwise indicated.
2. Extend joint fillers full width and depth of joint.
3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:
1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch radius. Repeat grooving of contraction joints after applying surface finishes.
a. Tolerance: Ensure that grooved joints are within 3 inches either way from centers of dowels.
2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
a. Tolerance: Ensure that sawed joints are within 3 inches either way from centers of dowels.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes.

3.5 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation and items to be embedded or cast-in.

B. Remove snow, ice, or frost from subbase surface before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.

F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

G. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating dowels and joint devices.

H. Screed paving surface with a straightedge and strike off.

I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.

K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.

1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

L. Cold-Weather Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
2. Do not use frozen materials or materials containing ice or snow.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

M. Hot-Weather Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms[, steel reinforcement,] and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.6 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
1. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch deep with a stiff-bristled broom, perpendicular to line of traffic.

3.7 DETECTABLE WARNINGS

A. Blockouts: Form blockouts in concrete for installation of detectable paving units specified in Section 32 14 00 "Unit Paving".
1. Tolerance for Opening Size: Plus 1/4 inch, no minus.

3.8 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound or a combination of these as follows:
1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
a. Water.
b. Continuous water-fog spray.
c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover, placed in widest practicable width, with sides and ends lapped at least 12 inches and sealed by waterproof tape or adhesive. Immediately repair any holes or tears occurring during installation or curing period using cover material and waterproof tape.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas that have been subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

3.9 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:
1. Elevation: 3/4 inch.
2. Thickness: Plus 3/8 inch, minus 1/4 inch.
3. Surface: Gap below 10-foot- long, unleveled straightedge not to exceed 1/2 inch.
4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches of tie bar.
5. Lateral Alignment and Spacing of Dowels: 1 inch.
6. Vertical Alignment of Dowels: 1/4 inch.
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches of dowel.
8. Joint Spacing: 3 inches.
9. Contraction Joint Depth: Plus 1/4 inch, no minus.
10. Joint Width: Plus 1/8 inch, no minus.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day.
a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when it is 80 deg F and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.
a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

G. Concrete paving will be considered defective if it does not pass tests and inspections.

H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

I. Prepare test and inspection reports.

3.11 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION

CONCRETE PAVING JOINT SEALANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Cold-applied joint sealants.
2. Joint-sealant backer materials.
3. Primers.

B. Related Requirements:
1. Section 07 92 00 "Joint Sealants" for sealing nontraffic and traffic joints in locations not specified in this Section.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- wide joints formed between two 6-inch- long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

C. Paving-Joint-Sealant Schedule: Include the following information:
1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.
3. Joint-sealant formulation.
4. Joint-sealant color.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Product Certificates: For each type of joint sealant and accessory.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Product Testing: Test joint sealants using a qualified testing agency.

1.6 FIELD CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:
1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer.
2. When joint substrates are wet.
3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

2.2 COLD-APPLIED JOINT SEALANTS

A. Single-Component, Nonsag, Silicone Joint Sealant: ASTM D 5893/D 5893M, Type NS.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Pecora Corporation; 301 NS.

-

B. Single-Component, Self-Leveling, Silicone Joint Sealant: ASTM D 5893/D 5893M, Type SL.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Pecora Corporation; 300 SL.

2.3 JOINT-SEALANT BACKER MATERIALS

A. Joint-Sealant Backer Materials: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by joint-sealant manufacturer, based on field experience and laboratory testing.

B. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D 5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

2.4 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning of Joints: Before installing joint sealants, clean out joints immediately to comply with joint-sealant manufacturer's written instructions.
   1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.3 INSTALLATION OF JOINT SEALANTS

A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions.

C. Install joint-sealant backings to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
   1. Do not leave gaps between ends of joint-sealant backings.
   2. Do not stretch, twist, puncture, or tear joint-sealant backings.
   3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants immediately following backing installation, using proven techniques that comply with the following:
   1. Place joint sealants so they fully contact joint substrates.
   2. Completely fill recesses in each joint configuration.
   3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of

configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:

1. Remove excess joint sealant from surfaces adjacent to joints.
2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

3.4 CLEANING AND PROTECTION

A. Clean off excess joint sealant as the Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.

B. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.

END OF SECTION

UNIT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Brick pavers set in bituminous setting beds.
   2. Cast-in-place concrete edge restraints.

B. Related Sections:
   1. Section 32 13 13 "Concrete Paving" for concrete base under unit pavers and for cast-in-place concrete curbs and gutters serving as edge restraints for unit pavers.

1.3 ACTION SUBMITTALS

A. Product Data: For materials other than water and aggregates.

B. Product Data: For the following:
   1. Pavers.
   2. Bituminous setting materials.

C. LEED Submittals:
   1. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.

D. Samples for Verification:
   1. Full-size units of each type of unit paver indicated.
   2. Joint materials.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of unit paver, joint material, and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

B. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.

B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

D. Store liquids in tightly closed containers protected from freezing.

E. Store asphalt cement and other bituminous materials in tightly closed containers.

1.6 PROJECT CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

B. Weather Limitations for Bituminous Setting Bed:
   1. Install bituminous setting bed only when ambient temperature is above 40 deg F and when base is dry.

2. Apply asphalt adhesive only when ambient temperature is above 50 deg F and when temperature has not been below 35 deg F for 12 hours immediately before application. Do not apply when setting bed is wet or contains excess moisture.

PART 2 - PRODUCTS

2.1 BRICK PAVERS

A. Regional Materials: Provide brick pavers that have been manufactured within 500 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site.

B. Light-traffic paving brick; “ADA/Tactile”.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. The Whitacre Greer Company, 1400 South Mahoning Ave., Alliance, OH 44601. Telephone: (800) 947-2837. Email: info@wgpaver.com.
b. Approved equal.
2. Thickness: 2-1/4 inches.
3. Face Size: 4 by 8 inches.
4. Color: 33 Dark Antique.

C. Efflorescence: Brick shall be rated "not effloresced" when tested according to ASTM C 67.

D. Temporary Protective Coating: Precoat exposed surfaces of brick pavers with a continuous film of a temporary protective coating that is compatible with brick, mortar, and grout products and can be removed without damaging grout or brick. Do not coat unexposed brick surfaces; handle brick to prevent coated surfaces from contacting backs or edges of other units. If, despite these precautions, coating does contact bonding surfaces of brick, remove coating from bonding surfaces before setting brick.

2.2 CURBS AND EDGE RESTRAINTS

A. Job-Built Concrete Edge Restraints: Comply with requirements in Section 03 30 00 "Cast-in-Place Concrete" for normal-weight, air-entrained, ready-mixed concrete with minimum 28-day compressive strength of 3000 psi.

2.3 BITUMINOUS SETTING-BED MATERIALS

A. Primer for Base: ASTM D 2028, cutback asphalt, grade as recommended by unit paver manufacturer.

B. Fine Aggregate for Setting Bed: ASTM D 1073, No. 2 or No. 3.

C. Asphalt Cement: ASTM D 3381, Viscosity Grade AC-10 or Grade AC-20.

D. Neoprene-Modified Asphalt Adhesive: Paving manufacturer's standard adhesive consisting of oxidized asphalt combined with 2 percent neoprene and 10 percent long-fibered mineral fibers containing no asbestos.

E. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 sieve and no more than 10 percent passing No. 200 sieve.
1. Provide sand of color needed to produce required joint color.

2.4 BITUMINOUS SETTING-BED MIX

A. Mix bituminous setting-bed materials at an asphalt plant in approximate proportion, by weight, of 7 percent asphalt cement to 93 percent fine aggregate unless otherwise indicated. Heat mixture to 300 deg F.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas indicated to receive paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Where pavers are to be installed over waterproofing, examine waterproofing installation, with waterproofing Installer present, for protection from paving operations, including areas where waterproofing system is turned up or flashed against vertical surfaces.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Remove substances from concrete substrates that could impair mortar bond, including curing and sealing compounds, form oil, and laitance.

B. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.

C. Proof-roll prepared subgrade according to requirements in Section 31 23 16 "Excavation" to identify soft pockets and areas of excess yielding. Proceed with unit paver installation only after deficient subgrades have been corrected and are ready to receive subbase and base course for unit pavers.

3.3 INSTALLATION, GENERAL

A. Do not use unit pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.

B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

C. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.
   1. For concrete pavers, a block splitter may be used.

D. Handle protective-coated brick pavers to prevent coated surfaces from contacting backs or edges of other units. If, despite these precautions, coating does contact bonding surfaces of brick, remove coating from bonding surfaces before setting brick.

E. Joint Pattern: As indicated.

F. Tolerances: Do not exceed 1/32-inch unit-to-unit offset from flush (lippage) nor 1/8 inch in 10 feet from level, or indicated slope, for finished surface of paving.

G. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
   1. Install job-built concrete edge restraints to comply with requirements in Section 03 30 00 "Cast-in-Place Concrete."

3.4 BITUMINOUS SETTING-BED APPLICATIONS

A. Apply primer to concrete slab or binder course immediately before placing setting bed.

B. Prepare for setting-bed placement by locating 3/4-inch- deep control bars approximately 11 feet apart and parallel to one another, to serve as guides for striking board. Adjust bars to subgrades required for accurate setting of paving units to finished grades indicated.

C. Place bituminous setting bed where indicated, in panels, by spreading bituminous material between control bars. Spread mix at a minimum temperature of 250 deg F. Strike setting bed smooth, firm, even, and not less than 3/4 inch thick. Add fresh bituminous material to low, porous spots after each pass of striking board. After each panel is completed, advance first control bar to next position in readiness for striking adjacent panels. Carefully fill depressions that remain after removing depth-control bars.
   1. Roll setting bed with power roller to a nominal depth of 3/4 inch. Adjust thickness as necessary to allow accurate setting of unit pavers to finished grades indicated. Complete rolling before mix temperature cools to 185 deg F.

D. Apply neoprene-modified asphalt adhesive to cold setting bed by squeegeeing or troweling to a uniform thickness of 1/16 inch. Proceed with setting of paving units only after adhesive is tacky and surface is dry to touch.

E. Place pavers carefully by hand in straight courses, maintaining accurate alignment and uniform top surface. Protect newly laid pavers with plywood panels on which workers can stand. Advance protective panels as work progresses, but maintain protection in areas subject to continued movement of materials and equipment to avoid creating depressions or disrupting alignment of pavers. If additional leveling of paving is required, and before treating joints, roll paving with power roller after sufficient heat has built up in the surface from several days of hot weather.

F. Joint Treatment: Place unit pavers with hand-tight joints. Fill joints by sweeping sand over paved surface until joints are filled. Remove excess sand after joints are filled.

3.5 REPAIRING

A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

END OF SECTION

SOIL PREPARATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes planting soils specified by composition of the mixes.

B. Related Requirements:
1. Section 31 10 00 "Site Clearing" for topsoil stripping and stockpiling.
2. Section 32 92 00 "Turf and Grasses" for placing planting soil for turf and grasses.
3. Section 32 93 00 "Plants" for placing planting soil for plantings.

1.3 DEFINITIONS

A. AAPFCO: Association of American Plant Food Control Officials.

B. Backfill: The earth used to replace or the act of replacing earth in an excavation. This can be amended or unamended soil as indicated.

C. CEC: Cation exchange capacity.

D. Compost: The product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth.

E. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.

F. Imported Soil: Soil that is transported to Project site for use.

G. Layered Soil Assembly: A designed series of planting soils, layered on each other, that together produce an environment for plant growth.

H. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.

I. NAPT: North American Proficiency Testing Program. An SSSA program to assist soil-, plant-, and water-testing laboratories through interlaboratory sample exchanges and statistical evaluation of analytical data.

J. Organic Matter: The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."

K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

L. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.

M. SSSA: Soil Science Society of America.

N. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

O. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

P. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.

Q. USCC: U.S. Composting Council.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include recommendations for application and use.

-

2. Include test data substantiating that products comply with requirements.
3. Include sieve analyses for aggregate materials.
4. Material Certificates: For each type of imported soil and soil amendment and fertilizer before delivery to the site, according to the following:
   a. Manufacturer's qualified testing agency's certified analysis of standard products.
   b. Analysis of fertilizers, by a qualified testing agency, made according to AAPFCO methods for testing and labeling and according to AAPFCO's SUIP #25.
   c. Analysis of nonstandard materials, by a qualified testing agency, made according to SSSA methods, where applicable.

B. LEED Submittals:
   1. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.

C. Samples: For each bulk-supplied material, 1-quart volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For each testing agency.

B. Preconstruction Test Reports: For preconstruction soil analyses specified in "Preconstruction Testing" Article.

C. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.

1.8 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction soil analyses on existing, on-site soil and imported soil.
   1. Notify Architect seven days in advance of the dates and times when laboratory samples will be taken.

B. Preconstruction Soil Analyses: For each unamended soil type, perform testing on soil samples and furnish soil analysis and a written report containing soil-amendment and fertilizer recommendations by a qualified testing agency performing the testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.
   1. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.

1.9 SOIL-SAMPLING REQUIREMENTS

A. General: Extract soil samples according to requirements in this article.

B. Sample Collection and Labeling: Have samples taken and labeled by Contractor in presence of Architect or state-certified, -licensed, or -registered soil scientist under the direction of the testing agency.
   1. Number and Location of Samples: Minimum of three representative soil samples from varied locations for each soil to be used or amended for landscaping purposes.
   2. Procedures and Depth of Samples: According to USDA-NRCS's "Field Book for Describing and Sampling Soils."
   3. Division of Samples: Split each sample into two, equal parts. Send half to the testing agency and half to Owner for its records.
   4. Labeling: Label each sample with the date, location keyed to a site plan or other location system, visible soil condition, and sampling depth.

1.10 TESTING REQUIREMENTS

A. General: Perform tests on soil samples according to requirements in this article.

B. Physical Testing:
   1. Soil Texture: Soil-particle, size-distribution analysis by one of the following methods according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods":
      a. Sieving Method: Report sand-gradation percentages for very coarse, coarse, medium, fine, and very fine sand; and fragment-gradation (gravel) percentages for fine, medium, and coarse fragments; according to USDA sand and fragment sizes.
      b. Hydrometer Method: Report percentages of sand, silt, and clay.
   2. Total Porosity: Calculate using particle density and bulk density according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
   3. Water Retention: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
   4. Saturated Hydraulic Conductivity: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods"; at 85% compaction according to ASTM D 698 (Standard Proctor).

C. Chemical Testing:
   1. CEC: Analysis by sodium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 3-Chemical Methods."
   2. Clay Mineralogy: Analysis and estimated percentage of expandable clay minerals using CEC by ammonium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 1- Physical and Mineralogical Methods."
   3. Metals Hazardous to Human Health: Test for presence and quantities of RCRA metals including aluminum, arsenic, barium, copper, cadmium, chromium, cobalt, lead, lithium, and vanadium. If RCRA metals are present, include recommendations for corrective action.
   4. Phytotoxicity: Test for plant-available concentrations of phytotoxic minerals including aluminum, arsenic, barium, cadmium, chlorides, chromium, cobalt, copper, lead, lithium, mercury, nickel, selenium, silver, sodium, strontium, tin, titanium, vanadium, and zinc.

D. Fertility Testing: Soil-fertility analysis according to standard laboratory protocol of SSSA NAPT NCR-13, including the following:
   1. Percentage of organic matter.
   2. CEC, calcium percent of CEC, and magnesium percent of CEC.
   3. Soil reaction (acidity/alkalinity pH value).
   4. Buffered acidity or alkalinity.
   5. Nitrogen ppm.
   6. Phosphorous ppm.
   7. Potassium ppm.
   8. Manganese ppm.
   9. Manganese-availability ppm.
   10. Zinc ppm.
   11. Zinc availability ppm.
   12. Copper ppm.
   13. Sodium ppm.
   14. Soluble-salts ppm.
   15. Presence and quantities of problem materials including salts and metals cited in the Standard protocol. If such problem materials are present, provide additional recommendations for corrective action.
   16. Other deleterious materials, including their characteristics and content of each.

E. Organic-Matter Content: Analysis using loss-by-ignition method according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."

F. Recommendations: Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy, viable plants indicated. Include, at a minimum, recommendations for nitrogen, phosphorous, and potassium fertilization, and for micronutrients.
   1. Fertilizers and Soil Amendment Rates: State recommendations in weight per 1000 sq. ft. for 6-inch depth of soil.
   2. Soil Reaction: State the recommended liming rates for raising pH or sulfur for lowering pH according to the buffered acidity or buffered alkalinity in weight per 1000 sq. ft. for 6-inch depth of soil.

-

1.11 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.

B. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Do not move or handle materials when they are wet or frozen.
   4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Regional Materials: Imported soil and soil amendments and fertilizers shall be manufactured within 500 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site.

2.2 PLANTING SOILS SPECIFIED BY COMPOSITION

A. General: Soil amendments, fertilizers, and rates of application specified in this article are guidelines that may need revision based on testing laboratory's recommendations after preconstruction soil analyses are performed.

B. Planting-Soil Type A: Existing, on-site surface soil, with the duff layer, if any, retained; and stockpiled on-site; modified to produce viable planting soil. Blend existing, on-site surface soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
   1. Ratio of Loose Compost to Soil: **1:3** by volume.
   2. Weight of Lime: Amount recommended in soil reports from a qualified soil-testing laboratory.
   3. Weight of Sulfur: Amount recommended in soil reports from a qualified soil-testing laboratory.
   4. Weight of Slow-Release Fertilizer: Amount recommended in soil reports from a qualified soil-testing laboratory.

C. Planting-Soil Type B: Imported, naturally formed soil from off-site sources and consisting of loam or silt loam according to USDA textures; and modified to produce viable planting soil.
   1. Sources: Take imported, unamended soil from sources that are naturally well-drained sites where topsoil occurs at least 4 inches deep, not from agricultural land, bogs, or marshes; and that do not contain undesirable organisms; disease-causing plant pathogens; or obnoxious weeds and invasive plants including, but not limited to, quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and bromegrass.
   2. Additional Properties of Imported Soil before Amending: Soil reaction of pH 6 to 7 and minimum of 4 percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration.
   3. Unacceptable Properties: Clean soil of the following:
      a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
      b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 8 percent by dry weight of the imported soil.
      c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding 2 inches in any dimension.
   4. Amended Soil Composition: Blend imported, unamended soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
      a. Ratio of Loose Compost to Soil: 1:3 by volume.
      b. Weight of Lime: Amount recommended in soil reports from a qualified soil-testing laboratory.
      c. Weight of Sulfur: Amount recommended in soil reports from a qualified soil-testing laboratory.
      d. Weight of Slow-Release Fertilizer: Amount recommended in soil reports from a qualified soil-testing laboratory.

-

2.3 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
   1. Class: T, with a minimum of 99 percent passing through a No. 8 sieve and a minimum of 75 percent passing through a No. 60 sieve.

B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a No. 6 sieve and a maximum of 10 percent passing through a No. 40 sieve.

2.4 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter produced by composting feedstock, and bearing USCC's "Seal of Testing Assurance," and as follows:
   1. Feedstock: Limited to leaves.
   2. Reaction: pH of 5.5 to 8.
   3. Soluble-Salt Concentration: Less than 4 dS/m.
   4. Moisture Content: 35 to 55 percent by weight.
   5. Organic-Matter Content: 50 to 60 percent of dry weight.
   6. Particle Size: Minimum of 98 percent passing through a 1/2-inch sieve.

B. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

2.5 FERTILIZERS

A. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
   1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

PART 3 - EXECUTION

3.1 GENERAL

A. Place planting soil and fertilizers according to requirements in other Specification Sections.

B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.

C. Proceed with placement only after unsatisfactory conditions have been corrected.

3.2 PREPARATION OF UNAMENDED, ON-SITE SOIL BEFORE AMENDING

A. Excavation: Excavate soil from designated area(s) to a depth of 6 inches and stockpile until amended.

B. Unacceptable Materials: Clean soil of concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.

C. Unsuitable Materials: Clean soil to contain a maximum of 8 percent by dry weight of stones, roots, plants, sod, clay lumps, and pockets of coarse sand.

D. Screening: Pass unamended soil through a 2-inch sieve to remove large materials.

3.3 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till subgrade to a minimum depth of 12 inches. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
   1. Apply, add soil amendments, and mix approximately half the thickness of unamended soil over prepared, loosened subgrade according to "Mixing" Paragraph below. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.

C. Mixing: Spread unamended soil to total depth of 6 inches, but not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.
   1. Amendments: Apply soil amendments**,** except compost, and fertilizer, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.
      a. Mix lime and sulfur with dry soil before mixing fertilizer.
      b. Mix fertilizer with planting soil no more than seven days before planting.
   2. Lifts: Apply and mix unamended soil and amendments in lifts not exceeding 8 inches in loose depth for material compacted by compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each blended lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D 698 and tested in-place.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.4 BLENDING PLANTING SOIL IN PLACE

A. General: Mix amendments with in-place, unamended soil to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Preparation: Till unamended, existing soil in planting areas to a minimum depth of 6 inches. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

C. Mixing: Apply soil amendments**,** except compost, and fertilizer, if required, evenly on surface, and thoroughly blend them into full depth of unamended, in-place soil to produce planting soil.
   1. Mix lime and sulfur with dry soil before mixing fertilizer.
   2. Mix fertilizer with planting soil no more than seven days before planting.

D. Compaction: Compact blended planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D 698.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.5 APPLYING COMPOST TO SURFACE OF PLANTING SOIL

A. Application: Apply compost component of planting-soil mix to surface of in-place planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Finish Grading: Grade surface to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests:
   1. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on laboratory testing according to ASTM D 698. Space tests at no less than one for each 1000 sq. ft. of in-place soil or part thereof.

C. Soil will be considered defective if it does not pass tests.

D. Prepare test reports.

E. Label each sample and test report with the date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

3.7 PROTECTION

A. Protection Zone: Identify protection zones according to Section 01 56 39 "Temporary Tree and Plant Protection."

B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:

-

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Vehicle traffic.
4. Foot traffic.
5. Erection of sheds or structures.
6. Impoundment of water.
7. Excavation or other digging unless otherwise indicated.

C. If planting soil or subgrade is over compacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by Architect and replace contaminated planting soil with new planting soil.

3.8 CLEANING

A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.

B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.
   1. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

END OF SECTION

TURF AND GRASSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Seeding.
   2. Turf renovation.
   3. Erosion-control material(s).

B. Related Requirements:
   1. Section 32 93 00 "Plants" for trees, shrubs, ground covers, and other plants as well as border edgings and mow strips.
   2. Section 33 46 00 "Subdrainage" for below-grade drainage of landscaped areas.

1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 32 91 13 "Soil Preparation" and drawing designations for planting soils.

E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer.

B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

C. Product Certificates: For fertilizers, from manufacturer.

D. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required maintenance periods.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf establishment.
   1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
   2. Experience: Five years' experience in turf installation in addition to requirements in Section 01 40 00 "Quality Requirements."
   3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the Professional Landcare Network:
   a. Landscape Industry Certified Technician - Exterior.
   b. Landscape Industry Certified Lawncare Manager.
   c. Landscape Industry Certified Lawncare Technician.
5. Pesticide Applicator: State licensed, commercial.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

B. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk materials with appropriate certificates.

1.9 FIELD CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Substantial Completion.
   1. Spring Planting: April 15th to May 30th.
   2. Fall Planting: September 1st to September 30th.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species:
   1. Turf-Type Tall Fescue; a minimum of four cultivars.

2.2 FERTILIZERS

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
   1. Composition: 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.

2.3 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

B. Asphalt Emulsion: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

2.4 PESTICIDES

A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

2.5 EROSION-CONTROL MATERIALS

A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.

B. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of 0.92 lb/sq. yd., with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches long.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.
   1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
   2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
   3. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
   1. Protect grade stakes set by others until directed to remove them.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 TURF AREA PREPARATION

A. General: Prepare planting area for soil placement and mix planting soil according to Section 32 91 13 "Soil Preparation."

B. Placing Planting Soil: Place planting soil according to Section 32 91 13 “Soil Preparation.”

C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

D. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 PREPARATION FOR EROSION-CONTROL MATERIALS

A. Prepare area as specified in "Turf Area Preparation" Article.

B. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.

C. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.5 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph.
   1. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
   2. Do not use wet seed or seed that is moldy or otherwise damaged.
   3. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at a total rate of 5 to 8 lb/1000 sq. ft.

C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas with slopes exceeding 1:4 with erosion-control blankets and 1:6 with erosion-control fiber mesh installed and stapled according to manufacturer's written instructions.

E. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2 inches in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.
   1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.
   2. Bond straw mulch by spraying with asphalt emulsion at a rate of 10 to 13 gal./1000 sq. ft.. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.

3.6 TURF RENOVATION

A. Renovate existing turf where indicated.

B. Renovate turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
   1. Reestablish turf where settlement or washouts occur or where minor regrading is required.
   2. Install new planting soil as required.

C. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.

D. Remove topsoil containing foreign materials, such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.

E. Mow, dethatch, core aerate, and rake existing turf.

F. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.

G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.

H. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches.

I. Apply soil amendments and initial fertilizer required for establishing new turf and mix thoroughly into top 4 inches of existing soil. Install new planting soil to fill low spots and meet finish grades.
   1. Soil Amendment(s): Apply soil amendments according to requirements of Section 32 91 13 "Soil Preparation” for “blending planting soil in place.”
   2. Initial Fertilizer: Commercial fertilizer applied according to manufacturer's recommendations.

J. Apply seed and protect with straw mulch as required for new turf.

K. Water newly planted areas and keep moist until new turf is established.

3.7 TURF MAINTENANCE

A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
   1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
   2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
   3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches.
   1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
   2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.

C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
   1. Mow turf-type tall fescue to a height of 2 to 3 inches.

D. Turf Postfertilization: Apply commercial fertilizer after initial mowing and when grass is dry.
   1. Use fertilizer that provides actual nitrogen of at least 1 lb/1000 sq. ft. to turf area.

3.8 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:
   1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.

B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

3.9 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.10 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

D. Remove nondegradable erosion-control measures after grass establishment period.

3.11 MAINTENANCE SERVICE

A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:
   1. Seeded Turf: 60 days from date of Substantial Completion.
      a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

END OF SECTION

PLANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Plants.
2. Tree-watering devices.
3. Landscape edgings.

B. Related Requirements:
1. Section 01 56 39 "Temporary Tree and Plant Protection" for protecting, trimming, pruning, repairing, and replacing existing trees to remain that interfere with, or are affected by, execution of the Work.
2. Section 32 92 00 "Turf and Grasses" for turf (lawn) and erosion-control materials.

1.3 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with a ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.

C. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required.

D. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than the minimum root spread according to ANSI Z60.1 for type and size of plant required.

E. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

F. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.

G. Finish Grade: Elevation of finished surface of planting soil.

H. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

I. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

J. Planting Area: Areas to be planted.

K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 32 91 13 "Soil Preparation" for drawing designations for planting soils.

L. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

M. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

N. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

O. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.4 COORDINATION

A. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.
   1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

1.5 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.
   2. Plant Photographs: Include color photographs in digital format of each required species and size of plant material as it will be furnished to Project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

B. Samples for Verification: For each of the following:
   1. Organic Mulch: 1-quart volume of each organic mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of color, texture, and organic makeup.
   2. Mineral Mulch: 2 lb of each mineral mulch required, in sealed plastic bags labeled with source of mulch. Sample shall be typical of the lot of material to be delivered and installed on-site; provide an accurate indication of color, texture, and makeup of the material.
   3. Weed Control Barrier: 12 by 12 inches.
   4. Slow-Release, Tree-Watering Device: One unit of each size required.
   5. Edging Materials and Accessories: Manufacturer's standard size, to verify color selected.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.

B. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:
   1. Manufacturer's certified analysis of standard products.
   2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

C. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

D. Sample Warranty: For special warranty.

1.8 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before expiration of required maintenance periods.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants.
   1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.

2. Experience: Five years' experience in landscape installation in addition to requirements in Section 01 40 00 "Quality Requirements."
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
4. Personnel Certifications: Installer's field supervisor shall have certification in **one** of the following categories from the Professional Landcare Network:
   a. Landscape Industry Certified Technician - Exterior.
   b. Landscape Industry Certified Horticultural Technician.
5. Pesticide Applicator: State licensed, commercial.

B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
1. Selection of plants purchased under allowances is made by Architect, who tags plants at their place of growth before they are prepared for transplanting.

C. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.
1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.
2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

D. Plant Material Observation: Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Architect may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.
1. Notify Architect of sources of planting materials 30 days in advance of delivery to site.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.

B. Bulk Materials:
1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk materials with appropriate certificates.

C. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

D. Handle planting stock by root ball.

E. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.
1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.

F. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

G. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Heel-in bare-root stock. Soak roots that are in less than moist condition in water for two hours. Reject plants with dry roots.
2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
3. Do not remove container-grown stock from containers before time of planting.
4. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

1.11 FIELD CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
1. Spring Planting: March 15th to April 30th.
2. Fall Planting: September 15th to October 31st.

C. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

1.12 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
1. Failures include, but are not limited to, the following:
a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner.
b. Structural failures including plantings falling or blowing over.
c. Faulty performance of edgings.
d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
2. Warranty Periods: From date of Substantial Completion.
a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.
3. Include the following remedial actions as a minimum:
a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
c. A limit of one replacement of each plant is required except for losses or replacements due to failure to comply with requirements.
d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots are unacceptable.
2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.

B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.

C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

D. Labeling: Label each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant.

E. If formal arrangements or consecutive order of plants is indicated on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

2.2 FERTILIZERS

A. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
   1. Size: 21-gram tablets.
   2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

2.3 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
   1. Type: Ground or shredded bark.
   2. Size Range: 3 inches maximum, 1/2 inch minimum.
   3. Color: Natural.

B. Mineral Mulch: Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of the following type, size range, and color:
   1. Type: Granite chips as manufactured by Kafka Granite, LLC, Stratford, WI.
   2. Size Range: 3/4 inch maximum, 1/4 inch minimum.
   3. Color: Imperial Gray Granite.

2.4 WEED-CONTROL BARRIERS

A. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally encountered chemicals, alkalis, and acids.

2.5 PESTICIDES

A. General: Pesticide registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

2.6 LANDSCAPE EDGINGS

A. Steel Edging: Standard commercial-steel edging, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Sure-loc Edging Corporation.
   2. Edging Size: 3/16 inch thick by 4 inches deep.
   3. Stakes: Tapered steel, a minimum of 15 inches long.
   4. Accessories: Standard tapered ends, corners, and splicers.
   5. Finish: Manufacturer's standard paint.
      a. Paint Color: Black.

2.7 TREE-WATERING DEVICES

A. Slow-Release Watering Device: Standard product manufactured for drip irrigation of plants and emptying its water contents over an extended time period; manufactured from UV-light-stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. BIO-PLEX.
      b. Engineered Watering Solutions; PQ Partners, LLC.
      c. Spectrum Products, Inc.
   2. Color: As selected by Architect from manufacturer's full range.

2.8 MISCELLANEOUS PRODUCTS

A. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.

B. Burlap: Non-synthetic, biodegradable.

C. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per lb of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.
   1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
   2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
   3. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
   4. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

D. Lay out plants at locations directed by Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

3.3 PLANTING AREA ESTABLISHMENT

A. General: Prepare planting area for soil placement and mix planting soil according to Section 32 91 13 "Soil Preparation."

B. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

C. Application of Mycorrhizal Fungi: At time directed by Architect, broadcast dry product uniformly over prepared soil at application rate according to manufacturer's written recommendations.

3.4 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits.
   1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
   2. Excavate approximately three times as wide as ball diameter for balled and burlapped and container-grown stock.
   3. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
   4. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
   5. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
   6. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
   7. Maintain supervision of excavations during working hours.
   8. Keep excavations covered or otherwise protected when unattended by Installer's personnel.
   9. If drain tile is indicated on Drawings or required under planting areas, excavate to top of porous backfill over tile.

B. Backfill Soil: Subsoil and topsoil removed from excavations may not be used as backfill soil unless otherwise indicated.

C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
   1. Hardpan Layer: Drill 6-inch- diameter holes, 24 inches apart, into free-draining strata or to a depth of 10 feet, whichever is less, and backfill with free-draining material.

D. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

E. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

3.5 TREE, SHRUB, AND VINE PLANTING

A. Inspection: At time of planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with root flare 1 inch above adjacent finish grades.
   1. Backfill: Planting soil type A or B. For trees, use excavated soil for backfill.
   2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
   3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
   4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
      a. Quantity: Three for each caliper inch of plant.
   5. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. Container-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare 1 inch above adjacent finish grades.
   1. Backfill: Planting soil type A or B. For trees, use excavated soil for backfill.
   2. Carefully remove root ball from container without damaging root ball or plant.
   3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
   4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
      a. Quantity: Three for each caliper inch of plant.
   5. Continue backfilling process. Water again after placing and tamping final layer of soil.

E. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.6 TREE, SHRUB, AND VINE PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.

C. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.

D. Do not apply pruning paint to wounds.

3.7 GROUND COVER AND PLANT PLANTING

A. Set out and space ground cover and plants other than trees, shrubs, and vines as indicated on Drawings in even rows with triangular spacing.

B. Use planting soil type A or B for backfill.

C. Dig holes large enough to allow spreading of roots.

D. For rooted cutting plants supplied in flats, plant each in a manner that minimally disturbs the root system but to a depth not less than two nodes.

E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.8 PLANTING AREA MULCHING

A. Mulch backfilled surfaces of planting areas and other areas indicated.
   1. Trees and Treelike Shrubs in Turf Areas: Apply organic mulch ring of 3-inch average thickness, with 24-inch radius around trunks or stems. Do not place mulch within 3 inches of trunks or stems.
   2. Organic Mulch in Planting Areas: Apply 3-inch average thickness of organic mulch extending 12 inches beyond edge of individual planting pit or trench and over whole surface of planting area where indicated, and finish level with adjacent finish grades. Do not place mulch within 3 inches of trunks or stems.
   3. Mineral Mulch in Planting Areas: Apply 2-inch average thickness of mineral mulch, where indicated, extending 12 inches beyond edge of individual planting pit or trench and over whole surface of planting area where indicated, and finish level with adjacent finish grades. Do not place mulch within 3 inches of trunks or stems.

3.9 EDGING INSTALLATION

A. Steel Edging: Install steel edging where indicated according to manufacturer's written instructions. Anchor with steel stakes spaced approximately 30 inches apart, driven below top elevation of edging.

B. Spade-Cut Edging: Separate mulched areas from turf areas, curbs, and paving with a 90-degree, 4- to 6-inch- deep, spade-cut edge as indicated on Drawings.

C. Mow-Strip Installation:
   1. Excavate for mow strip as indicated on Drawings.
   2. Compact subgrade uniformly beneath mow strip.
   3. Apply nonselective, pre-emergent herbicide that inhibits growth of grass and weeds.
   4. Install steel edging, delineating the edge of mow strip.
   5. Install weed-control barrier before mulching, covering area of mow strip, and overlapping and pinning edges of barrier at least 6 inches and according to manufacturer's written instructions.
   6. Place indicated thickness of mineral mulch, fully covering weed barrier.
   7. Rake mulch to a uniform surface level with adjacent finish grades.

3.10 INSTALLING SLOW-RELEASE WATERING DEVICE

A. Provide one device for each tree.

B. Place device on top of the mulch at base of tree stem and fill with water according to manufacturer's written instructions.

3.11 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings.

B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

3.12 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Pre-Emergent Herbicides (Selective and Nonselective): Apply to tree, shrub, and ground-cover areas according to manufacturer's written recommendations. Do not apply to seeded areas.

C. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.13 REPAIR AND REPLACEMENT

A. General: Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Architect.
   1. Submit details of proposed pruning and repairs.
   2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.
   3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.

B. Remove and replace trees that are more than 25 percent dead or in an unhealthy condition before the end of the corrections period or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.
   1. Provide new trees of same size as those being replaced for each tree of 6 inches or smaller in caliper size.
   2. Species of Replacement Trees: Same species being replaced.

3.14 CLEANING AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

C. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

D. After Substantial Completion and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

E. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

3.15 MAINTENANCE SERVICE

A. Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:
   1. Maintenance Period: Three months from date of Substantial Completion.

B. Maintenance Service for Ground Cover and Other Plants: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:
   1. Maintenance Period: Three months from date of Substantial Completion.

END OF SECTION

SITE WATER UTILITY DISTRIBUTION PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe and fittings for Site water line, including domestic water line and fire water line.
2. Gate valves.
3. Hydrants and yard hydrants.
4. Underground pipe markers.
5. Valve boxes.
6. Bedding and cover materials.

B. Related Requirements:

1. Section 03 30 00 - Cast-in-Place Concrete: Concrete for thrust restraints.
2. Section 22 11 00 - Facility Water Distribution: Product and execution requirements for domestic water piping at building.
3. Section 31 05 13 - Soils for Earthwork: Soils for backfill in trenches.
4. Section 31 05 16 - Aggregates for Earthwork: Aggregate for backfill in trenches.
5. Section 31 23 16 - Excavation: Product and execution requirements for excavation and backfill.
6. Section 31 23 17 - Trenching: Execution requirements for trenching.
7. Section 31 23 23 - Fill: Requirements for backfill to be placed by this Section.
8. Section 33 13 00 - Disinfecting of Water Utility Distribution: Disinfection of Site service utility water piping.

1.2 REFERENCE STANDARDS

A. ASTM International:

1. ASTM A48 - Standard Specification for Gray Iron Castings.
2. ASTM C858 - Standard Specification for Underground Precast Concrete Utility Structures.
3. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
4. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
5. ASTM D2241 - Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure Rated Pipe (SDR Series).
6. ASTM D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
7. ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.

B. American Welding Society:

1. AWS A5.8 - Specification for Filler Metals for Brazing and Braze Welding.

C. American Water Works Association:

1. AWWA C500 - Metal-Seated Gate Valves for Water Supply Service.
2. AWWA C502 - Dry-Barrel Fire Hydrants.
3. AWWA C509 - Resilient-Seated Gate Valves for Water Supply Service.
4. AWWA C606 - Grooved and Shouldered Joints.
5. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Transmission and Distribution.

D. Underwriters Laboratories Inc.:

1. UL 246 - Standard for Safety Hydrants for Fire-Protection Service.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit data on pipe materials, pipe fittings, valves, and accessories.

1.4 SUSTAINABLE DESIGN SUBMITTALS

A. Section 01 81 13 - Sustainable Design Requirements: Requirements for sustainable design submittals.

B. Manufacturer's Certificate: Certify that the products meet or exceed specified sustainable design requirements.

1. Materials Resources Certificates:

a. Certify recycled material content for recycled content products.

b. Certify source for regional materials and distance from Project Site.

C. Product Cost Data: Submit cost of products to verify compliance with Project sustainable design requirements. Exclude cost of labor and equipment to install products.

1. Provide cost data for the following products:

a. Products with recycled material content.

b. Regional products.

1.5 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for submittals.

B. Project Record Documents:

1. Record actual locations of piping mains, valves, connections, thrust restraints, and invert elevations. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.6 QUALITY ASSURANCE

A. Perform Work according to AWWA standards.

PART 2 PRODUCTS

2.1 WATER PIPING

A. PVC Pipe:

1. AWWA C900 DR 18 Class.

2. Fittings: AWWA C110/A2110, ductile iron, with mechanical joints.

3. Joints: ASTM D3139 compression gasket ring.

2.2 GATE VALVES

A. 3 in and Larger: AWWA C509, iron body, bronze trim, non-rising stem with square nut, single wedge, resilient seat, mechanical joint ends, control rod, valve box, and valve key.

B. Mark manufacturer's name and pressure rating on valve body.

2.3 FIRE HYDRANTS

A. Hydrants: According to City of Richmond fire department requirements.

2.4 UNDERGROUND PIPE MARKERS

A. Plastic Ribbon Tape: Bright colored, continuously printed, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

B. Trace Wire:

1. Electronic detection materials for non-conductive piping products.

2. Unshielded, 10 gage, THWN-insulated copper wire.

3. Conductive tape.

2.5 VALVE BOXES

A. Valve Boxes: Furnish materials according to AWWA standards.

B. Description: Valve boxes and covers containing position indicators and valve extensions, as indicated on Drawings..
C. Type: Cast iron; extension type; slide adjustment.
D. Covers: Marked WATER SERVICE.

2.6 SUSTAINABILITY CHARACTERISTICS

A. Section 01 81 13 - Sustainable Design Requirements: Requirements for sustainable design compliance.
B. Materials and Resources Characteristics:
1. Recycled Content Materials: Furnish materials with maximum available recycled content.
2. Regional Materials: Furnish materials extracted, processed, and manufactured within 500 miles of Project Site.

2.7 MATERIALS

A. Bedding and Cover:
1. Bedding: Fill as shown on drawings.
2. Cover: Fill Type as shown on drawings.
3. Soil Backfill from above Pipe to Finish Grade:
a. Soil Type as shown on drawings.

2.8 ACCESSORIES

A. Concrete for Thrust Restraints: Concrete type as specified in Section 03 30 00 - Cast-in-Place Concrete.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation examination.
B. Verify building service connection and municipal utility water main size, location, and invert are as indicated on Drawings.

3.2 PREPARATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation preparation.
B. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, remove burrs.
C. Remove scale and dirt on inside and outside before assembly.
D. Prepare pipe connections to equipment with flanges or unions.
E. Protect and support existing distribution piping and appurtenances as Work progresses.

3.3 BEDDING

A. Excavate pipe trench according to Section 31 23 17 - Trenching for Work of this Section.
B. Form and place concrete for pipe thrust restraints at change of pipe direction. Place concrete to permit full access to pipe and pipe accessories. Provide thrust restraint bearing on subsoil.
C. Place bedding material at trench bottom, level fill materials in one continuous layer 4 inch compacted depth.
D. Backfill around sides and to top of pipe with cover fill, tamp in place. Fill to a minimum 12” over pipe or as shown on drawings.

3.4 INSTALLATION - PIPE

A. Maintain separation of water main from sewer piping according to AWWA code.
B. Route pipe in straight line.
C. Install access fittings to permit disinfection of water system as required.
D. Form and place concrete for thrust restraints at each elbow or change of direction of pipe main.
E. Bury piping with not less than 54 inches of cover.

F. Install plastic ribbon tape continuous over top of pipe buried 6 inches below finish grade, coordinate with Section 31 23 17.

G. Install trace wire continuous over top of pipe per details and specifications on drawings.

H. Backfill trench according to Drawings.

3.5 INSTALLATION - VALVES AND HYDRANTS

A. Set valves on solid bearing.

B. Center and plumb valve box over valve. Set box cover flush with finished grade.

C. Set hydrants plumb; locate pumper nozzle perpendicular to and facing roadway.

D. Set hydrants to grade, with nozzles at least 20 in above ground.

E. Locate control valve minimum 12 inches away from hydrant.

F. Provide drainage pit 36 in square by 24 in deep, filled with 2 in washed gravel. Encase elbow of hydrant in gravel to 6 in above drain opening. Do not connect drain opening to sewer.

G. Paint hydrants according to City of Richmond Fire Department guidelines.

3.6 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

A. Flush and disinfect system according to AWWA standards.

3.7 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Requirements for inspecting and testing.

B. Perform pressure test on domestic Site water distribution system according to AWWA C600.

1. When test of pipe indicates leakage greater than allowed, locate source of leakage, make corrections, and retest until leakage is within allowable limits. Correct visible leaks regardless of quantity of leakage.

C. When tests indicate Work does not meet specified requirements, remove Work, replace, and retest.

END OF SECTION

SANITARY UTILITY SEWERAGE PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Sanitary sewage pipe.
   2. Underground pipe markers.
   3. Bedding and cover materials.

B. Related Sections:
   1. Section 31 05 13 - Soils for Earthwork: Soils for backfill in trenches.
   2. Section 31 05 16 - Aggregates for Earthwork: Aggregate for backfill in trenches.
   3. Section 31 23 16 - Excavation: Product and execution requirements for excavation and backfill required by this section.
   4. Section 31 23 17 - Trenching: Execution requirements for trenching required by this section.
   5. Section 31 23 23 - Fill: Requirements for backfill to be placed by this section.

1.2 REFERENCES

A. ASTM International:
   1. ASTM C14 - Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe.
   2. ASTM C76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
   3. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
   4. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
   5. ASTM D2729 - Standard Specification for Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
   6. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

1.3 DEFINITIONS

A. Bedding: Fill placed under, beside and directly over pipe, prior to subsequent backfill operations.

1.4 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit data indicating pipe material used and pipe accessories.

1.5 SUSTAINABLE DESIGN SUBMITTALS

A. Section 01 81 13 - Sustainable Design Requirements: Requirements for sustainable design submittals.

B. Manufacturer's Certificate: Certify products meet or exceed specified sustainable design requirements.
   1. Materials Resources Certificates:
      a. Certify recycled material content for recycled content products.
      b. Certify source for regional materials and distance from Project site.

C. Product Cost Data: Submit cost of products to verify compliance with Project sustainable design requirements. Exclude cost of labor and equipment to install products.
   1. Provide cost data for the following products:
      a. Products with recycled material content.
      b. Regional products.

1.6 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for submittals.

B. Project Record Documents: Record location of pipe runs, connections, manholes, cleanouts, and invert elevations. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.7 QUALITY ASSURANCE

A. Perform Work in accordance with INDOT Standards.

1.8 PRE-INSTALLATION MEETINGS

A. Section 01 30 00 - Administrative Requirements: Pre-installation meeting.

B. Convene minimum one week prior to commencing work of this section.

1.9 FIELD MEASUREMENTS

A. Verify field measurements and elevations are as indicated.

1.10 COORDINATION

A. Section 01 30 00 - Administrative Requirements: Coordination and project conditions.

B. Coordinate the Work with termination of sanitary sewer connection outside building, connection to campus/municipal sewer utility service, and trenching.

PART 2 PRODUCTS

2.1 SUSTAINABILITY CHARACTERISTICS

A. Section 01 81 13 - Sustainable Design Requirements: Requirements for sustainable design compliance.

B. Materials and Resources Characteristics:

1. Recycled Content Materials: Furnish materials with maximum available recycled content .

2. Regional Materials: Furnish materials extracted, processed, and manufactured within 500 miles of Project site.

2.2 SANITARY SEWAGE PIPE

A. Plastic Pipe: ASTM D3034, SDR 35, Poly (Vinyl Chloride) (PVC) material; inside nominal diameter as shown, bell and spigot style rubber ring sealed gasket joint.

1. Fittings: PVC.

2. Joints: ASTM F477, elastomeric gaskets.

2.3 UNDERGROUND PIPE MARKERS

A. Plastic Ribbon Tape: Bright colored, continuously printed, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

B. Trace Wire: Magnetic detectable conductor, brightly colored plastic covering.

2.4 BEDDING AND COVER MATERIALS

A. Bedding: See drawings for material types in various areas.

B. Cover: See drawings for material types in various areas.

C. Soil Backfill from Above Pipe to Finish Grade: See drawings for material types in various areas.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify trench cuts and excavation bases are ready to receive work and excavations, dimensions, and elevations are as indicated on drawings.

3.2 PREPARATION

A. Correct over excavation with fine aggregate.

B. Remove large stones or other hard matter which could damage pipe or impede consistent backfilling or compaction.

3.3 BEDDING

A. Excavate pipe trench in accordance with Drawings.

B. Place bedding material at trench bottom, level materials in continuous layer not exceeding 4 inches.

C. Maintain optimum moisture content of bedding material to attain required compaction density.

3.4 INSTALLATION - PIPE

A. Install pipe, fittings, and accessories in accordance with ASTM D2321. Seal joints watertight.

B. Lay pipe to slope gradients noted on drawings; with maximum variation from indicated slope of 1/8 inch in 10 feet.
C. Install bedding at sides and over top of pipe to minimum compacted thickness of 12 inches.
D. Refer to Drawings for backfilling and compacting requirements. Do not displace or damage pipe when compacting.
E. Connect to building sanitary sewer outlet and municipal sewer system.
F. Install plastic ribbon tape continuous over top of pipe buried 6 inches below finish grade.
G. Install trace wire continuous over top of pipe per details and specifications on drawings.
H. Install site sanitary sewage system piping to 5 feet of building. Connect to building sanitary waste system.

3.5 FIELD QUALITY CONTROL

A. Section 01 70 00 - Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.
B. Perform test on site sanitary sewage system in accordance with Richmond Sanitary District standards.

3.6 PROTECTION OF FINISHED WORK

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for protecting finished Work.
B. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.

END OF SECTION

STORM UTILITY DRAINAGE PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Storm drainage piping.
   2. Accessories.
   3. Underground pipe markers.
   4. Catch basins and area drains.
   5. Cleanouts.
   6. Bedding and cover materials.

B. Related Sections:
   1. Section 22 14 00 - Facility Storm Drainage: Product and execution requirements for storm drainage piping within 5 feet (1500 mm) of building.
   2. Section 31 05 13 - Soils for Earthwork: Soils for backfill in trenches.
   3. Section 31 05 16 - Aggregates for Earthwork: Aggregate for backfill in trenches.
   4. Section 31 23 16 - Excavation: Product and execution requirements for excavation and backfill required by this section.
   5. Section 31 23 17 - Trenching: Execution requirements for trenching required by this section.
   6. Section 31 23 23 - Fill: Requirements for backfill to be placed by this section.
   7. Section 33 05 13 - Manholes and Structures.

1.2 REFERENCES

A. ASTM International:
   1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
   2. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).
   3. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
   4. ASTM D2729 - Standard Specification for Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
   5. ASTM D2751 - Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings.
   6. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit data indicating pipe and pipe accessories.

1.4 SUSTAINABLE DESIGN SUBMITTALS

A. Section 01 81 13 - Sustainable Design Requirements: Requirements for sustainable design submittals.

B. Manufacturer's Certificate: Certify products meet or exceed specified sustainable design requirements.
   1. Materials Resources Certificates:
      a. Certify recycled material content for recycled content products.
      b. Certify source for regional materials and distance from Project site.

C. Product Cost Data: Submit cost of products to verify compliance with Project sustainable design requirements. Exclude cost of labor and equipment to install products.
   1. Provide cost data for the following products:
      a. Products with recycled material content.
      b. Regional products.

1.5 CLOSEOUT SUBMITTALS
- A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for submittals.
- B. Project Record Documents:
  1. Provide As-Built drawings of all underground work.
  2. Accurately record actual locations of pipe runs, connections, and invert elevations. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.6 QUALITY ASSURANCE
- A. Perform Work in accordance with Indiana Department of Transportation (INDOT) Standards.

1.7 PRE-INSTALLATION MEETINGS
- A. Section 01 30 00 - Administrative Requirements: Pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.8 COORDINATION
- A. Section 01 30 00 - Administrative Requirements: Coordination and project conditions.
- B. Coordinate the Work with termination of storm sewer connection outside building, trenching, tree planting areas, etc.

PART 2 PRODUCTS

2.1 SUSTAINABILITY CHARACTERISTICS
- A. Section 01 81 13 - Sustainable Design Requirements: Requirements for sustainable design compliance.
- B. Materials and Resources Characteristics:
  1. Recycled Content Materials: Furnish materials with maximum available recycled content.
  2. Regional Materials: Furnish materials extracted, processed, and manufactured within 500 miles of Project site.

2.2 STORM DRAINAGE PIPING
- A. Plastic Pipe: High Density polyethelene (HDPE) material.

2.3 UNDERGROUND PIPE MARKERS
- A. Plastic Ribbon Tape: Bright colored, continuously printed, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.
- B. Trace Wire: Magnetic detectable conductor, plastic covering.

2.4 CATCH BASINS AND PLANT AREA DRAINS
- A. Catch Basin: Precast box
- B. Catch Basin Lid and Frame:
  1. Construction: Cast iron construction.
  2. Lid Design: per drawings.

2.5 CLEANOUTS
- A. Cleanout materials:
  1. Plastic HPDE accessories.

PART 3 EXECUTION

3.1 EXAMINATION
- A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify trench cuts and excavation bases are ready to receive work and excavations, dimensions, and elevations are as indicated on drawings.

3.2 PREPARATION
- A. Correct over excavation with fine aggregate.
- B. Remove large stones or other hard matter which could damage piping or impede consistent backfilling or compaction.

3.3 BEDDING

A. Excavate pipe trench in accordance with Drawings for work of this Section. Place bedding material at trench bottom, level materials in continuous layer 4 inches compacted depth.

B. Maintain optimum moisture content of bedding material to attain required compaction density.

3.4 INSTALLATION - PIPE

A. Install pipe, fittings, and accessories in accordance with INDOT standards. Seal joints watertight.

B. Place pipe on minimum 4 inch deep bed of fine aggregate.

C. Lay pipe to slope gradients noted on drawings with maximum variation from indicated slope of 1/8 inch in 10 feet.

D. Install aggregate or flowable fill at sides and over top of pipe. Install as shown on drawings.

E. Refer to Drawings for backfilling and compacting requirements. Do not displace or damage pipe when compacting.

F. Install plastic ribbon tape continuous over top of pipe buried 6 inches below finish grade.

G. Install trace wire continuous over top of pipe per detail and specifications on drawings.

H. Connect to subdrainage tile system piping.

I. Install site storm drainage system piping to 5 feet of building. Connect to building storm drainage system.

J. Install Work in accordance with INDOT Standards.

3.5 INSTALLATION - CATCH BASINS AND CLEANOUTS

A. Form bottom of excavation clean and smooth to correct elevation.

B. Establish elevations and pipe inverts for inlets and outlets as indicated on Drawings.

C. Install Work in accordance with INDOT standards.

3.6 FIELD QUALITY CONTROL

A. Section 01 70 00 - Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.

B. Request inspection prior to placing aggregate cover over pipe.

3.7 PROTECTION OF FINISHED WORK

A. Section 01 70 00 - Execution and Closeout Requirements: Protecting finished Work.

B. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.

1. Take care not to damage or displace installed pipe and joints during construction of pipe supports, backfilling, testing, and other operations.

2. Repair or replace pipe that is damaged or displaced from construction operations.

END OF SECTION