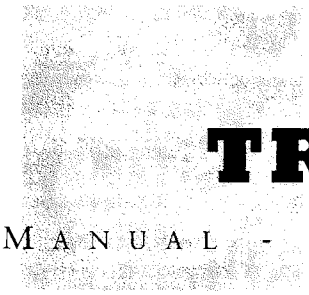

PROJECT MANUAL - VOLUME TWO

Package 'H' - Charles Street Project
Permit Set/Not for Construction
Date of Issue: September 24, 2004

PROJECT

Maine Medical Center
Charles Street Project
MMC Project No. 21084A
Architect's Commission Number 4673

OWNER

Maine Medical Center
22 Bramhall Street
Portland, Maine 04102-3175

ARCHITECT

The Ritchie Organization
80 Bridge Street
Newton, Massachusetts 02458

CONSULTANTS

Civil Engineer / Landscape
Sebago Technics, Inc.
One Chabot Street
P.O. Box 1339
Westbrook, Maine 04098-1339

Structural Engineer
Simpson Gumpertz & Heger Inc.
41 Seyon Street, Building 1, Suite 500
Waltham, Massachusetts 02453

HVAC, Plumbing, Fire Protection, and Electrical Engineering
The Ritchie Organization
80 Bridge Street
Newton, Massachusetts 02458

CONSTRUCTION MANAGEMENT

William A. Berry & Son, Inc.
100 Conifer Hill Drive
Danvers, Massachusetts 01923

ARCHITECTURE PLANNING ENGINEERING INTERIOR DESIGN

TRO / The Ritchie Organization

80 Bridge Street, Newton, MA 02458-1134 **T** 617.969.9400 **F** 617.527.6753

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PROJECT MANUAL - VOLUME TWO

DIVISION 15 - MECHANICAL

DIVISION 16 - ELECTRICAL

END OF SECTION 00005

SECTION 15050 - BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1. Section 01045 - Cutting and Patching: Openings in masonry, concrete, tile, and other parts of structure, except drilling for hangers, providing holes and openings in metal decks, and core drilling.
2. Section 01150 - Special Provisions: Coordination drawings.
3. Section 01300 - Submittals and Substitutions.
4. Section 01700 - Contract Closeout.
5. Section 01720 - Project Record Documents.
6. Section 01500 - Temporary Facilities and Controls: Sanitary facilities for use during construction.
7. Section 02070 - Selective Demolition: Removal of demolished mechanical piping systems and equipment.
8. Section 02220 - Excavation, Filling, and Rough Grading: Trench excavation, pipe bedding, and backfilling.
9. Section 03010 - Concrete Form Work: Housekeeping pads and inertia pads for vibrating equipment.
10. Section 05500 - Metal Fabrications: Structural supports necessary to distribute loading from equipment to roof or floor.
11. Section 07270 - Firestops and Smoke seals: Caulking of pipe and duct penetrations through floor slabs and fire-rated partitions.
12. Section 07560 - Membrane Roofing System: Flashing of roof penetrations and roof drains.
13. Section 07600 - Flashing and Sheet Metal.
14. Section 07920 - Sealants and Caulking: Sealing joints between plumbing fixtures and abutting surfaces.
15. Section 08305 - Access Panels: Access to concealed mechanical devices.
16. Section 09510 - Acoustical Ceilings: Removal of existing ceilings for new work under Division 15.
17. Section 09900 - Painting: Painting of exposed piping and equipment except as specified in this Section.
18. Section 15055-HVAC Motors.
19. Section 15056-HVAC Variable Frequency Drives.
20. Section 15060-HVAC Hangers and Supports.
21. Section 15071-Mechanical Vibration and Seismic Control.
22. Section 15075-Mechanical Identification.

23. Section 15081-Duct Insulation.
24. Section 15082-Equipment Insulation.
25. Section 15083-Pipe Insulation.
26. Section 15110-Valves.
27. Section 15121-Pipe Expansion Fittings and Loops.
28. Section 15122-Meters and Gauges.
29. Section 15181-Hydronic Piping.
30. Section 15182-Steam and Condensate Piping.
31. Section 15183-Refrigerant Piping.
32. Section 15185-Hydronic Pumps.
33. Section 15186-Steam Condensate Pumps.
34. Section 15189-HVAC Water Treatment.
35. Section 15300-Fire Protection.
36. Section 15420-Plumbing Systems.
37. Section 15440-Plumbing Fixtures.
38. Section 15480-Medical Gas Systems.
39. Section 15490-Medical Gas Systems Testing.
40. Section 15710-Heat Exchangers.
41. Section 15711-Packaged Heat Transfer Modules.
42. Section 15736-Self-Contained Air-Conditioners.
43. Section 15752-Humidifiers.
44. Section 15764-Radiators.
45. Section 15766-Cabinet Unit Heaters.
46. Section 15767-Propeller Unit Heaters.
47. Section 15769-Radiant Panels.
48. Section 15772-Radiant heating Piping.
49. Section 15815-Metal Ducts.
50. Section 15820-Duct Accessories.
51. Section 15837-Centrifugal Fans.
52. Section 15838-Power Ventilators
53. Section 15845-Air Terminals.
54. Section 15854-Custom Air Handling unit.
55. Section 15855-Diffusers, Registers, and Grilles.
56. Section 15861-Air Filters.
57. Section 15900-HVAC Instrumentation and Controls.
58. Section 15990-Testing, Adjusting, and Balancing.
59. Section 16050-Basic Electrical Materials and Methods.

1.2 SUMMARY

A. This Section includes the following:

1. Submittal Requirements.
2. Substitutions.
3. Coordination drawings.

4. Dust and Airborne Contaminants Control.
5. Phasing requirements.Phasing requirements.
6. Piping materials and installation instructions common to most piping systems.
7. Transition fittings.
8. Dielectric fittings.
9. Core drilling.
10. Penetrations.
11. Mechanical sleeve seals.
12. Sleeves.
13. Escutcheons.
14. Grout.
15. Mechanical demolition.
16. Equipment installation requirements common to equipment sections.
17. Painting and finishing.
18. Concrete bases.
19. Supports and anchorages.
20. Record documents.
21. Systems start-ups and Commissioning.

1.3 DESIGN PARAMETERS

A. Outdoor Design Conditions

Winter design dry bulb	-3° F
Summer design dry bulb	83° F
Coincident wet bulb.	74° F

B. Indoor Design Conditions

Room	Temperature	Humidity
LDRP Rooms	70° F to 75° F	30% - 50% RH
Examination Rooms	75°F	30% - 50% RH
Deliv. Rooms/C-Sect.	68° F to 73° F	30% - 60% RH
Nursery ICU	72° F to 78° F	30% - 60% RH
Isolation Rooms	75° F	30% - 50% RH
Patient Rooms	70° F to 75° F	30% - 50% RH
Triage	70° F to 75° F	30% - 50% RH
ICU Rooms	70° F to 75° F	30% - 50% RH
Administrative Rms	70° F to 75° F	30% - 50% RH
Conference Rooms	70° F to 75° F	30% - 50% RH

C. Ventilation

Ventilation standards shall be based on ASHRAE Standard 62-1989 "Ventilation for Acceptable Indoor Air Quality Including Requirements for Outside Air" and "Guidelines for Con-

struction and Equipment of Hospitals and Medical Facilities - 1996-97 Edition". The more stringent for each space will be used.

D. Filtration

Filtration shall be as follows:

	Filter No. 1	Filter No. 2
All areas for inpatient care, treatment And diagnosis, and those areas providing Direct service or clean supplies such as Sterile and clean processing.	30 Percent	90 Percent

C. Ventilation

Ventilation standards shall be based on ASHRAE Standard 62-1989 "Ventilation for Acceptable Indoor Air Quality Including Requirements for Outside Air" and "Guidelines for Construction and Equipment of Hospitals and Medical Facilities - 1996-97 Edition". The more stringent for each space will be used.

1.31.4 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, 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 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 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.

1.41.5 SUBMITTALS

A. General Requirements: Comply with pertinent provisions of Division 1 Section "Submittals and Substitutions", the Sections of Division 15-Mechanical, and the additional requirements of this Section.

1. Copies of faxed pages within submittal packages will be rejected.

B. Materials List: Within 30 calendar days after the Contractor has received the Owner's Notice to proceed, submit a list of the proposed materials to be provided under the work of the Mechanical Sections of Division 15.

C. Organization of Submittals: Bind submittals into comprehensible packages with related product data sheets organized and identified by Specification Section and Article numbers. Bind submittals into packages as specified in the Sections of Division 15. Identify submittal pages to indicate the specific equipment or fixture type the data sheet applies to. Submittals that are not properly bound and identified may be returned without review.

1. Indicate appropriate model numbers in manufacturers' brochures and cross out non-applicable information.
2. Copies of faxed pages are unacceptable.
3. Submit shop drawings for particular systems complete, simultaneously, and organized by system.

D. Schedule of Shut-downs: After the project construction schedule is developed, submit the following information to the Owner for all required shut-downs of existing systems.

1. Date of proposed shut-down.
2. List of systems to be affected.
3. List of areas affected by the shut-down.
4. Description of work to be performed.
5. Estimated length of the shut-down.

E. Piping Systems Schedule: Prepare and submit a schedule of mechanical piping systems to indicate the piping material, joints, and fittings to be used with each system.

F. Insulation Schedule: Prepare and submit a schedule to indicate insulation types and thicknesses to be used on each mechanical piping system.

G. UL Through-Penetration Firestop System Schedule: Prepare and submit a schedule to indicate the UL-System number for through-penetration assemblies to be used with all mechanical systems. Coordinate with the work of Division 7 Section "Firestops and Smokeseals".

H. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

I. Welding certificates.

J. Record Drawings: Prepare record drawings in accordance with the provisions of Division 1 Section "Project Record Documents" and the additional requirements of this Section.

K. Operation and Maintenance Manuals: Prepare and submit copies of the Operation and Maintenance Manuals as specified in Division 1 Section "Contract Close-Out", Division 1 Section "Operation and Maintenance Data", and in Article 1.10 of this Section.

1.51.6 QUALITY ASSURANCE

A. Qualifications: Use adequate numbers of skilled, licensed workers who are thoroughly trained and experienced and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

B. Standard of Quality: The manufacturers names specified first or scheduled on the drawings are used for the design and to establish the standard of quality upon which the Contract is based. Acceptable manufacturers names are listed to provide competitive bids with the specified or scheduled manufacturer.

1. The inclusion of a manufacturer's name within the list of acceptable manufacturers does not necessarily mean that the manufacturers standard product is equal to the specified or scheduled product without some required modification. The submitted product shall be equal in all respects to the specified product.

C. Substitutions: Substitutions include manufacturers not listed as acceptable within the specifications, or products, systems and methods that differ from the specified systems.

1. Comply with the provisions of Division 1 Section "Submittals and Substitutions". Submit list of proposed substitutes for review and approval in compliance with Article 3 of the Instructions to Bidders, AIA Document A701.

2. It is the Contractor's responsibility to verify that the products of acceptable manufacturers and proposed substitutes meet or exceed the performance of the specified or scheduled product including the following:

a. Horsepower: Equal or less.
b. Efficiency: Equal or greater.
c. Capacities: Equal or greater.
d. Space/Clearances: Equal or greater.
e. Storage and Recovery: Equal or greater.
f. Warranty: Equal or better.
g. Weight (Lbs): Equal or less.
h. Noise: Equal or quieter.

3. By the submission of a proposed substitution, the Contractor represents that he has reviewed the proposed substitution and certifies that:

a. The proposed substitution does not affect dimensions shown on drawings.
b. Changes to the building design, including A/E design and review time at a rate of 2.7 x DPE, detailing and construction costs caused by the requested substitution will be included in the bid price with no additional cost to the Owner.
c. The proposed substitution will have no adverse affect on other trades, the construction schedule, or specified warranty requirements.
d. Maintenance and service parts are available locally.
e. All costs associated with the use of the proposed substitute will be covered by the Contractor.

D. Qualifications for Welding and Brazing Work:

1. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
2. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

a. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
b. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1) If re-certification of welders is required, re-testing will be Contractor's responsibility.

1.61.7 CODES, STANDARDS, AND REGULATIONS

A. Perform all work in strict accordance with all applicable Rules, Laws, Regulations, Codes, and Ordinances of Local, State, and Federal Governments.

1. In addition to complying with the specified requirements, comply with pertinent regulations of authorities that have jurisdiction.
2. In case of conflict between or among specified requirements and pertinent regulations, the more stringent requirement shall govern when so directed by the Architect.

B. Copies of Regulations and Standards: Obtain the most recent copies of the applicable regulations and standards and retain at the Project site to be available for reference by parties who have a reasonable need.

C. Applicability of Standards: Unless the Contract Documents include more stringent requirements, applicable construction industry standards have the same force and effect as if bound or copied directly into the Contract Documents to the extent referenced. Such standards are made a part of the Contract Documents by reference.

1. In addition to complying with the specified requirements, comply with pertinent regulations of governmental agencies, authorities having jurisdiction, and all local and state building, plumbing, mechanical, electrical, fire, and health department codes and standards.

2. BOCA MECHANICAL CODE(1993).

3. BOCA Code (1999).

4. City of Portland Code of Ordinances, Section 6-1.

5. Building and Building Regulations, Chapter 6.

   Rev. 12-1-00
   Article II. Building Code
   Article IV, Mechanical Code.
   Article III, Electrical Code.

6. State Energy Efficiency Building Performance Standards.

7. ASHRAE/INESNA Standard 90-1.

8. National Fire Protection Association (NFPA-101-2000 Life/Safety Code).

9. Guidelines for Construction and Equipment of Hospitals and Medical Facilities - 2001 Edition.

10. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

11. NFPA 54, 1996 Edition.

12. ADA Accessibility Guidelines(1991).

13. Elevator code ANSI/ASME A17.1-1996.

14. City of Portland Code of Ordinances, section 14-1, land use, chapter 14, rev 2-21-01.

15. Maine Plumbing Code.

16. National Electric code 1999 Edition.

17. Sheet Metal and Air Conditioning Contractor's National Association (SMACNA).

18. Occupational Safety and Health Act (OSHA).

19. Factory Mutual Association (FM).

20. Underwriters' Laboratories (UL).

21. UL Through Penetration Fire Stop Systems.

22. SMACNA Fire Damper Installation Guide.

D. Publication Dates: Comply with standards in effect as of the date of the Contract Documents, unless otherwise indicated.

1.8 WARRANTY

A. Upon completion of the Work, and as a condition of its acceptance, deliver to the Architect two copies of a written Warranty agreeing to replace the work of each mechanical section which fails due to defective materials or workmanship within one year after Date of Substantial Completion. Date of Substantial Completion shall be as determined in accordance with the General Conditions.

B. Failure due to defective materials or workmanship is deemed to include, but not to be limited to:

1. Failures in operating component or components.
2. Leakage from piping system.
3. Code violations.

C. The use of systems or equipment provided under Division 15 Sections for temporary services and facilities shall not constitute Final Acceptance of work nor beneficial use by the Owner, and shall not institute the Warranty period.

D. Obtain written equipment and material warranties offered in manufacturers published data without exclusion or limitation, in Owner's name.

E. Replace material and equipment that require excessive service during guarantee period as defined and as directed by Architect.

F. Guarantee shall include 24-hour service of complete system during guarantee period at no cost to Owner. Choice of service organization shall be subject to Owner's approval.

G. Submit guarantee to Architect before final payment and include in the Operation and Maintenance Manuals.

H. At end of guarantee period, transfer manufacturer's equipment and material warranties still in force to Owner.

I. This Article shall not be interpreted to limit Owner's rights under applicable codes and laws and under this Contract.

1.81.9 PROJECT CONDITIONS

A. Comply with Article 2 of the Instructions to Bidders, AIA Document A701, including the Appendix. Visit the site prior to submission of bids and examine existing conditions to be familiar with the related implications to the Work of the Mechanical Sections.

B. Questions regarding the Bidding Documents: Submit questions and requests for clarifications in compliance with the Instructions to Bidders.

C. Contract Documents: The Contract Drawings are diagrammatic and do not show every fitting and component and shall be used in conjunction with the specified requirements to provide complete and functional systems. The drawings and specifications are complimentary, and the requirements indicated on both establish the requirements of the Contract.

D. Document Review: Review the complete set of Contract Documents and be familiar with the space requirements of other trades. Thoroughly review building sections, architectural details, and mechanical and electrical drawings for a complete understanding of the scope and coordination requirements of the Mechanical Sections.

E. Scheduled Equipment: Standard manufacturers model numbers scheduled on the drawings shall be modified as specified in the descriptive specification for the scheduled equipment. The drawings generally define quantities, and the specifications further define equipment quality and system components, which may not be included in the standard model number.

F. Pipe sizing notations: Pipe sizing notations run along the pipe from the larger sizes to the smaller size. Sections of pipe that are not specifically identified with a pipe size are the continuation of the previous larger pipe size indication. Pipe sizes change only where indicated by a notation change.

G. Existing Conditions: The existing conditions indicated on the contract drawings are taken largely from existing record drawings and past field investigation by project architects and engineers. Conditions may have been renovated and/or changed without the knowledge of the project architect and engineer since field investigations were performed. Preparation work by

the contractor responsible for the mechanical sections includes the verification of existing conditions before the start of related installation work.

1.91.10 DUST AND AIRBORNE CONTAMINANTS CONTROL

A. Comply with the requirements of dust and airborne contaminant control as specified in Division 1 Section – "Dust and Airborne Contaminants Control".

1.101.11 COORDINATION

A. Prepare coordination drawings as specified in Division 1 Section "Special Provisions".

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

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

D. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors and Frames."

1.111.12 DELIVERY, STORAGE, AND HANDLING

A. Protection: Use all means necessary to protect materials of the Mechanical Sections before, during and after installation and to protect installed work and materials of all trades and Sections.

1. 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.
2. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

B. Replacements: In the event of damage, immediately make all repairs and replacement necessary to the approval of the Architect at no change in Contract Sum.

1.121.13 MANUALS AND INSTRUCTIONS

A. Comply with pertinent provisions of Division 1 Section "Contract Closeout".

B. Operation and Maintenance Manuals: Provide three copies for each item requiring Operation and Maintenance manuals. Bind Manuals in hard-cover, three-ring binders, and provide identi-

fied dividers with tabs. Indicate appropriate model numbers in manufacturers' brochures and cross out non-applicable information. Review the Manuals with the Owner's maintenance personnel and add additional maintenance data sheets and information as directed by the Owner's Representatives. Copies of faxed pages are unacceptable.

C. Division of Manuals: Divide manuals with tabs to match the mechanical specification sections.

D. Each Manual shall include:

1. Table of contents.
2. Subcontractor's warranties.
3. Name and telephone number of local representative or supplier.
4. Manufacturers' maintenance procedures.
5. Exploded drawings and parts lists.
6. Troubleshooting checklists with potential problems and possible causes.
7. Schematic wiring diagrams.
8. Record drawings.
9. Valve tag charts.
10. Equipment warranties and guaranties.
11. Additional requirements specified in the mechanical sections.

E. Instruction Seminar: Perform systems instruction seminar and walk-through with the Owner's representatives after preparation and review of the Operation and Maintenance manuals.

1.131.14 RECORD DOCUMENTS

A. Prepare record documents for the work of Division 15 as specified in Division 1 Section "Project Record Documents". The record drawings shall accurately indicate all valve locations and shall clearly show the assigned valve tag number. Record drawings shall include.

1. Piping and equipment location changes from the Contract Documents.
2. Valve locations and valve tag numbers.
3. Equipment identification numbers coordinated with the Owner's Facility Management Program.

B. Record drawings include ductwork fabrication drawings or coordination drawings prepared under the work of this Contract. Provide polyester mylar reproducible drawings of both the Contract Drawings and additional fabrication/coordination drawings that indicate mechanical systems.

C. Submission of the specified polyester mylars of the full mechanical coordination drawings eliminates the requirement to modify the Contract Drawings to incorporate the changes to piping and equipment locations made during construction.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 15 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.

2.2 JOINING MATERIALS

A. Refer to individual Division 15 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 (3.2-mm) 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.

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

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

E. 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.

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

2.3 DIELECTRIC FITTINGS

A. Victaulic Clearflow Dielectric Waterways – No substitutions.

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

2.4 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 & 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: 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.

2.5 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) 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.

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. 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 and rough brass.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: 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.

2.7 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 (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Inspect site conditions before starting preparatory work and verify that actual conditions are known and acceptable before starting work.

B. Inspect areas where piping and equipment will be installed and verify adequate space is available for access, service and removal of equipment. Coordinate with the Work of other Sections.

C. Notify the Architect immediately when the removal of existing ceilings, walls, or obstructions reveal conditions substantially different from the Contract Documents.

3.2 PREPARATION

A. Perform coordination with the work of other Sections and prepare composite coordination drawings as specified in Section 01150 "Special Provisions" before starting installation work of this section.

B. Verify points of connection to existing systems before proceeding with any related installation work.

3.3 SYSTEM SHUTDOWNS

A. Coordination shutdowns of existing systems with the Owner and submit a written request at least ten working days in advance. Minimize system shut downs as much as possible. Submit a list of all effected areas, the proposed work to be performed, and the expected length of the shut-down including time for re-testing.

B. Provide temporary services to maintain active system during extended shut-downs as required for demolition and construction phasing.

3.4 MECHANICAL DEMOLITION

A. Refer to Division 1 Sections "Cutting and Patching" and "Selective Demolition" for general demolition requirements and procedures. A drill stop shall be used on all core drilling applications.

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

1. Prior to demolition of any HVAC air system or hydronic system, provide pre-balance information as required on the plans and elsewhere in the specifications.

1.2. Piping to Be Removed: Remove portion of piping indicated to be removed and cap remaining piping with same or compatible piping material. Return to the owner all valve tags for valves removed from all demolished piping systems.
2.3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and cap remaining ducts with same or compatible ductwork material.
3.4. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4.5. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
5.6. 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.

3.5 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 15 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 Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with polished chrome-plated finish.
   f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
   g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
   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-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: Split-casting, cast-brass type with rough-brass finish.
   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 unless noted otherwise below.

N. 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 (50 mm) 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 (6.4-mm) 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 (DN 150).
    b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) 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 (50 mm) above finished floor level. Refer to Division 7 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 7 Section "Joint Sealants" for materials and installation.

O. 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 (150 mm) in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) 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.

P. 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 (25-mm) 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.

Q. 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 7 Section "Through-Penetration Firestop Systems" for materials.

R. Verify final equipment locations for roughing-in.

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

3.6 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 15 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.

3.7 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 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 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.

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

3.9 PAINTING

A. Painting of mechanical systems, equipment, and components is specified in Division 9 Section "Painting".

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

3.10 ACCESS PANELS

A. Access Panels: Comply with Section 08305.

B. Furnish access panels for installation under other sections to allow access to mechanical equipment and devices installed under Division 15. Furnish access panels for mechanical devices installed behind permanent construction such as gypsum wall board partitions and ceilings or concrete masonry walls and partitions.

C. Mechanical devices that require access include, but are not necessarily limited to; valves, clean-outs, air release valves; water hammer arrestors, terminal boxes; fire and smoke dampers, smoke detectors, steam traps, filters, coils, volume and control dampers.

D. Access panels shall be large enough to provide access for maintenance and removal of mechanical devices.

3.11 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 (100 mm) 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 (450-mm) 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 (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 3.

3.12 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 5 Section "Metal Fabrications" for structural steel.

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

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

3.13 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages 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.

3.14 GROUTING

A. Mix and install grout for mechanical 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 15050

SECTION 15055 – MOTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes basic requirements for factory-installed motors on related motor-driven equipment.

B. Related Sections include the following:

1. Division 15 Section "Mechanical Vibration and Seismic Controls" for mounting motors and vibration isolation and seismic-control devices.
2. Division 15 Sections for application of motors and reference to specific motor requirements for motor-driven equipment.

1.3 DEFINITIONS

A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

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.

B. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices. Provide motors that are:

1. Compatible with the following:

a. Magnetic controllers.

b. Reduced-voltage controllers.
c. Auto-transformer type 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.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

A. Motor requirements apply to factory-installed motors except as follows:

1. Different ratings, performance, or characteristics for a motor are specified in another Section.
2. Manufacturer for a factory-installed motor requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

2.2 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.

E. Service Factor: According to NEMA MG 1, unless otherwise indicated.

F. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) 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, unless otherwise indicated.

2.3 POLYPHASE MOTORS

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

1. Design Characteristics for Open Drip-Proof Motors: NEMA MG 1, Design E, all motors larger than ½ horsepower; to meet or exceed the following efficiencies for open drip proof motors:

Premium Efficiency Motor Minimum Efficiencies OPEN DRIP- PROOF (ODP)			
SIZE HP	Speed (RPM)		
	1200	1800	3600
	NEMA Nominal Efficiency		
1	82.5%	85.5%	80.0%
1.5	86.5%	86.5%	85.5%
2	87.5%	86.5%	86.5%
3	89.5%	89.5%	86.5%
5	89.5%	89.5%	89.5%
7.5	91.7%	91.0%	89.5%
10	91.7%	91.7%	90.2%
15	92.4%	93.0%	91.0%
20	92.4%	93.0%	92.4%
25	93.0%	93.6%	93.0%
30	93.6%	94.1%	93.0%
40	94.1%	94.1%	93.6%
50	94.1%	94.5%	93.6%
60	95.0%	95.0%	94.5%
75	95.0%	95.4%	94.5%
100	95.0%	95.4%	94.5%
125	95.4%	95.4%	95.0%
150	95.8%	95.8%	95.4%
200	95.4%	95.8%	95.4%
250	95.4%	95.8%	95.0%

2. Design Characteristics for Totally Enclosed Fan-Cooled Motors: NEMA MG 1, Design E, all motors larger than ½ horsepower; to meet or exceed the following efficiencies for totally enclosed fan-cooled motors:

Premium Efficiency Motor Minimum Efficiencies TOTALLY ENCLOSED FAN-COOLED (TEFC)			
SIZE HP	Speed (RPM)		
	1200	1800	3600
	NEMA Nominal Efficiency		
1	82.5%	85.5%	78.5%
1.5	87.5%	86.5%	85.5%
2	88.5%	86.5%	86.5%
3	89.5%	89.5%	88.5%

Premium Efficiency Motor Minimum Efficiencies TOTALLY ENCLOSED FAN-COOLED (TEFC)			
SIZE HP	Speed (RPM)		
	1200	1800	3600
	NEMA Nominal Efficiency		
5	89.5%	89.5%	89.5%
7.5	91.7%	91.7%	91.0%
10	91.7%	91.7%	91.7%
15	92.4%	92.4%	91.7%
20	92.4%	93.0%	92.4%
25	93.0%	93.6%	93.0%
30	93.6%	93.6%	93.0%
40	94.1%	94.1%	93.6%
50	94.1%	94.5%	94.1%
60	94.5%	95.0%	94.1%
75	95.5%	95.4%	94.5%
100	95.4%	95.4%	95.0%
125	95.4%	95.4%	95.4%
150	95.8%	95.8%	95.4%
200	95.8%	96.2%	95.8%
250	95.4%	95.8%	95.4%

B. Stator: Copper windings, unless otherwise indicated.

C. Rotor: Squirrel cage, unless otherwise indicated.

D. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.

E. Temperature Rise: Match insulation rating, unless otherwise indicated.

F. Insulation: Class F, unless otherwise indicated.

G. Code Letter Designation:

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

H. Enclosure: Cast iron for motors 7.5 HP and larger; rolled steel for motors smaller than 7.5 HP.

1. Finish: Gray enamel.

2.4 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: 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 H.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Source Quality Control: 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.

2.5 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, prelubricated-sleeve type for other single-phase motors.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Perform acceptance tests as follows and include the report in the emergency, operation, and maintenance manuals specified in Division 1 and Division 15 Section "Basic Mechanical Materials and Methods":

1. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
2. Test interlocks and control features for proper operation.
3. Verify that current in each phase is within nameplate rating.
4. Inspect field-assembled components, equipment installation, and piping and electrical connections for compliance with requirements.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
6. Verify bearing lubrication.

3.2 ADJUSTING

A. Align motors, bases, shafts, pulleys and belts. Tension belts according to manufacturer's written instructions.

3.3 CLEANING

A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean motors, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 15055

SECTION 15056 – VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes basic requirements for motor driven equipment controlled with variable frequency drives.

B. Related Sections include the following:

1. Division 15 Section "Mechanical Vibration and Seismic Controls" for mounting of variable frequency drives.

1.3 SUBMITTALS

A. General: Comply with pertinent provisions of Division 1 Section "Submittals and Substitutions" and Division 15 Section "Basic Mechanical Materials and Methods".

B. Product data for each variable frequency drive including the following:

1. A schedule of all variable frequency drives provided under this Section of the specifications including the following information:
   a. Variable frequency drive identification tag. (corresponding to Drawings)
   b. Manufacturer model number.
   c. Input voltage, phase and frequency.
   d. Horsepower rating, rated KVA, and output current amps.
   e. Weight, dimensions, and NEMA enclosure type.
2. Provide a list of all variable frequency drive protective features and circuits, programmable adjustments, required environmental conditions, display type, and information available for display during drive operation.
3. Provide manufacturer's electrical requirements for power supply wiring (to) and power output wiring (from) variable frequency drives. Submittal shall include ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory installed and portions that are field installed.
4. Provide submittal information on all variable frequency drive accessories and options.

C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

D. Harmonic Requirements:

1. Calculations

a. Under both normal and emergency operating conditions, the line harmonics introduced into the power system from the AC variable frequency drives shall be within the distortion limits as defined be IEEE-519 (1992). THD (voltage) shall not exceed 5% when measured at the point of common coupling. Note that the emergency generator(s) may become a point of common coupling during emergency operating conditions. The VFD manufacturer shall coordinate with the local utility company and with the manufacturer of the emergency generator(s) to obtain the impedance data required for the analysis.

b. In addition to the distortion limitations specified, the drives shall not create line notching in excess of the limits called for in IEEE-519 (1992) under the same conditions specified above.

c. The VFD manufacturer shall provide the following as a minimum, for each drive furnished for this project:

1) Provide three phase AC input line reactors.
2) Provide three phased tuned harmonic trap filters on all variable frequency drives serving motors 25 horsepower and larger.

d. The drive manufacturer shall include with his submittals a harmonic analysis which shall indicate the calculated level of voltage and current distortion and maximum line notching expected. The submittal shall include as a minimum the following information:

1) All input data and assumptions.
2) Explanation of method used to perform the analysis.
3) All calculations and/or computer printouts used in the analysis.
4) A system impedance diagram based on the Electrical one-line diagram(s).
5) A detailed description of the tests, procedures and supporting calculations required to substantiate the installed systems compliance with the specified THD limits. The description shall include information on the proposed test equipment and test conditions. Include the name and qualifications of the firm, which will conduct the field tests.

E. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around variable frequency drives. Show variable frequency drive layout and relationship between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

F. Test Reports: Written reports specified in Parts 2 and 3.

G. Operation and Maintenance Data: For each type of variable frequency drive to include in the emergency, operation, and maintenance manuals specified in Division 1 and Division 15 Section "Basic Mechanical Materials and Methods".

1.4 COORDINATION

A. Coordinate variable frequency drives support with requirements for access for maintenance and installation of accessories.

B. Coordinate size and location of concrete bases for floor mounted variable frequency drives. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain, within 100 miles (160 km) of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Source Limitations: Obtain variable frequency drives through one source from a single manufacturer.

C. Installer Qualifications: Engage an experienced Installer who has successfully installed variable frequency drives for use in similar applications.

D. Comply with the latest edition of the following list of publications:

1. Institute of Electrical and Electronic Engineers: Standard 519-1992, IEEE Guide for Harmonic Content and Control.
2. National Fire Protection Association: NFPA 70: National Electric Code.
3. National Electrical Manufacturers Association: NEMA 250: Enclosures for Electrical Equipment.
4. National Electrical Manufacturers Association: NEMA ICS 7.0: AC Adjustable Speed Drives.
5. National Electrical Manufacturers Association: NEMA MG 1-1993, Revision 1: Motors and Generators.
6. Underwriters Laboratories: UL 508: Industrial Control Equipment

E. Listing and Labeling: Provide variable frequency drives specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

1.6 COORDINATION

A. Coordinate features, accessories, and functions of each variable frequency drive with the ratings and characteristics of the supply circuit, the motor, the required control sequence, and the duty cycle of the motor and load.

1.7 WARRANTY

A. The special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of Contract Documents.

B. Manufacturer's Special Warranty: Written warranty, signed by manufacturer agreeing to a full parts and labor on-site warranty on all variable frequency drives for a period of two years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary. - ACH 400 Series.
2. Toshiba International Corporation, - Q-Flowsaver II Series.
3. MagneTek Drives and Systems, - GPD-506 Series.
4. York International, - Air Modulator VI Series.

2.2 GENERAL

A. Description: NEMA ICS 2, variable-frequency drive, listed and labeled as a complete unit and arranged to provide variable speed of a standard NEMA MG 1-1993 Revision 1, Design E, High efficiency, 3-phase, induction motor by adjusting output voltage and frequency.

B. Design and Rating: Provide variable frequency drives of capacities and with voltage requirements as indicated on Drawings. 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. The variable frequency drive shall be provided with the following:

1. The variable frequency drive shall be solid state, with a Pulse Width Modulated (PWM) output waveform.
2. The variable frequency drive shall employ a full wave bridge rectifier to prevent input line notching.
3. DC bus choke.
4. DC bus filter capacitors.
5. Utilize Insulated Gate Bipolar Transistors (IGBT's) as the switching device.

6. The variable frequency drive shall maintain a power factor of not less than 0.95 throughout its speed range.

2.3 ENCLOSURE

A. Description: NEMA 250, Type 1.

B. Mounting: Wall mounted or floor mounted.

2.4 ENVIRONMENTAL CONDITIONS

A. The variable frequency drives shall be designed to operate within the following environmental and service conditions:

1. Input Voltage: As indicated on the Drawings.
   a. Variable frequency drive designed to operate +/- 10% of scheduled input voltage.
2. Input Frequency: 60 Hz +/- 3%.
3. Ambient operating temperature: 0°F to 104°F.
4. Storage Temperature: 40°F to 104°F.
5. Relative Humidity: 90% Maximum, Non-Condensing.
6. Altitude: 3,000 feet above sea level - Maximum.

2.5 CONTROL

A. The variable frequency drives shall be designed to operate with the following design and control features:

1. Control Method: The variable frequency drive output shall be a Pulse Width Modulated (PWM) wave form. The variable frequency drive shall be configured with a 6-pulse convertor.
2. Optional Control Method: The variable frequency drive output shall be a Pulse Width Modulated (PWM) wave form. The variable frequency drive shall be configured with a 12-pulse convertor section comprised of two full wave bridge rectifiers, and an integral three-winding phase-shifting transformer to reduce harmonic current distortion.
3. Carrier Frequency Switching: Optimized and factory preset to reduce motor noise.
4. Output Frequency: 0 Hz to 120 Hz.

2.6 DISPLAY AND USER INTERFACE

A. The variable frequency drives shall have a digital keypad for performing all parameter adjustments and programming. The digital keypad shall have as a minimum the following features:

1. Up and down arrow keys for adjustment of motor speed and adjustment of programming parameters

2. "Start/Stop" key for starting and stopping in manual mode.

B. The variable frequency drives shall have a LED or LCD display. The variable frequency drive shall have the following operating information displays:

1. Output Frequency.
2. Motor Current.
3. Output Voltage.
4. Status.

2.7 OPERATING FUNCTIONS/FEATURES/ADJUSTMENTS

A. The variable frequency drives shall have the following operating features, functions, and adjustments:

1. Provide two (2) independently adjustable acceleration/deceleration ramps adjustable from 1 to 1200 seconds.
2. Provide a minimum of two (2) programmable critical frequency lockout ranges to prevent the variable frequency drive from continuously operating at an unstable speed.
3. Provide a PI Setpoint controller allowing a pressure or flow signal to be connected to the variable frequency drive, using the microprocessor in the variable frequency drive for closed loop control.
4. Provide a minimum of two (2) programmable digital inputs for interfacing with direct digital control or energy management systems.
5. Provide one (1) analog output proportional to frequency and output current.
6. Provide a minimum of two (2) digital outputs.
7. Provide a minimum of two (2) programmable analog inputs which shall accept a current or voltage signal for speed reference, or for reference and actual signals for PI controller. The minimum and maximum values (gain and offset) shall be adjustable within the range of 0-20 mA and 0-10 Volts.
8. Provide a minimum of seven (7) programmable preset speeds.
9. The variable frequency drive shall have the capability of either ramping or coasting to a stop, as selected by the user.
10. The variable frequency drive shall have an automatic extended power loss ride-through circuit that will utilize the inertia load to keep the drive powered. Minimum power loss ride-through shall be one cycle, based on full load and no inertia.
11. The variable frequency drive shall be capable of restarting into a rotating load (forward) and accelerate or decelerate to set-point without safety tripping or component damage.
12. The variable frequency drive shall have the ability to automatically restart after momentary power loss, momentary over-voltage, or loss of input reference signal. Upon loss of input reference signal, the drive shall operate at a preset minimum speed.

2.8 PROTECTIVE FEATURES

A. Provide self-protection and reliability features with fault indicators which shall be displayed on the front panel, including the following:

1. Ground fault protection.
2. Over-current protection.
3. Over-voltage protection.
4. Under-voltage protection.
5. Over-temperature protection.
6. Electronic motor overload protection.

B. Provide current limiting circuit with the following features:

1. The current limiting circuit shall be adjustable from 0 to 100 percent of the variable frequency drive's variable torque current rating. This adjustment shall be made via the keypad and shall be displayed in amps or as percent of full load.
2. Provide current limited stall prevention during acceleration, deceleration, and run conditions.
3. Current "switch-off" limit shall be fixed at a minimum of 120 percent of the variable frequency drive's variable torque rating for 60 seconds.

2.9 ACCESSORIES

A. Provide the following accessories with each variable frequency drive. The accessories shall be factory installed by the variable frequency drive manufacturer:

1. Door interlocked circuit breaker, padlockable in the "OFF" position.

   a. The circuit breaker Ampere Interupting Capacity (A.I.C) shall be 65,000 AMPS.
2. Provide a terminal strip for connection of fire, smoke, freeze, and external start command. Terminal strip shall allow for connection into the Building Automation System. All external interlocks shall remain fully functional whether in the "Hand", "Auto", or "Bypass" modes. External "Start/Stop" shall be functional only in the "Auto" mode.
3. Provide a Manual Bypass Circuit for all variable frequency drives 40 horsepower and smaller. Provide manual bypass with the following features:

   a. The bypass circuit shall allow the user to manually bypass the variable frequency drive and transfer control of the motor across-the-line, running the motor at full speed. The manual bypass circuit shall provide across-the-line-starting capability. When in the "Normal" mode of operation, the bypass contactor shall be closed. In the "Test" position both contactors shall be open, and in the "Bypass" position, the variable frequency drive output contactor shall be open, and the bypass contactor is closed. The variable frequency drive output contactor shall also open when a stop command is given, isolating the motor from the variable frequency drive. While in the bypass mode of operation, the motor shall be protected by a fuse or circuit breaker. A three-position selector switch to control the bypass contactor and the variable frequency drive output contactor shall be mounted on the enclosure door. Start/Stop signals and safety interlocks shall remain fully functional with variable frequency drive in "Normal" and "Bypass" modes of operation.
   b. Provide a bimetallic thermal motor overload relay to protect the motor in bypass mode of operation.

c. Provide a service switch to electrically isolate the variable frequency drive while in bypass mode, without having to remove power from the motor. This will provide the user with the ability to service the drive when in the bypass mode of operation.

4. Provide a Manual Bypass Circuit with soft start capability for all variable frequency drives 50 horsepower and larger. Provide manual bypass with the following features:

a. The bypass circuit shall allow the user to manually bypass the variable frequency drive. The manual bypass circuit shall provide solid state, reduced voltage starting capability. When in the "Normal" mode of operation, the bypass contactor shall be closed. In the "Test" position both contactors shall be open, and in the "Bypass" position, the variable frequency drive output contactor shall be open, and the bypass contactor is closed. The variable frequency drive output contactor shall also open when a stop command is given, isolating the motor from the variable frequency drive. While in the bypass mode of operation, the motor shall be protected by a fuse or circuit breaker. A three-position selector switch to control the bypass contactor and the variable frequency drive output contactor shall be mounted on the enclosure door. Start/Stop signals and safety interlocks shall remain fully functional with variable frequency drive in "Normal" and "Bypass" modes of operation.

b. b. Provide a bimetallic thermal motor overload relay to protect the motor in bypass mode of operation.

c. c. Provide a service switch to electrically isolate the variable frequency drive while in bypass mode, without having to remove power from the motor. This will provide the user with the ability to service the drive when in the bypass mode of operation.

d. Provide a solid-state, reduced-voltage controller on the manual bypass circuit. Controller shall be NEMA ICS 2, suitable for use with standard NEMA MG 1, Design B, poly-phase, medium induction motors. Controller shall have adjustable acceleration rate control uses voltage or current ramp, and adjustable starting torque control has up to 500 percent current limitation for 20 seconds. Provide a surge suppressor in solid-state power circuits provides 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage. Provide LED indicators show motor and control status, including the following conditions:

1) Control power available.
2) Controller on.
3) Overload trip.
4) Loss of phase.
5) Shorted silicon-controlled rectifier.

2.10 LINE REACTORS

A. Manufacturers: Subject to compliance with requirements, provide input line reactors by the following:

1. Trans Coil Inc., (TCI,) Milwaukee WI.

a. Sine Guard, KLR Series.

B. Provide three phase AC input line reactors on each variable frequency drive. The AC line reactors are to provide attenuation of the line side voltage transients, thus preventing over-voltage trips or other unnecessary variable frequency drive shutdowns, as well as, a reduction in harmonic current distortion. The AC line reactors shall have the following features:

1. Minimum of 2 ½% line impedance.
2. Saturation rating of no less than 2.5 times the continuous current rating.
3. UL listed.

2.11 TUNED HARMONIC TRAP FILTERS

A. Manufacturers: Subject to compliance with requirements, provide tuned harmonic trap filters by the following:

1. Trans Coil Inc., (TCI,) Milwaukee WI.

a. Harmonic Guard - Type L.

B. Provide tuned harmonic trap filters on all variable frequency drives serving motors 25 horsepower and larger, regardless of the harmonic voltage distortion and harmonic current distortion analysis results required in Part 1 of this Section.

C. Trap filters shall be enclosed in a NEMA 250, Type 1 enclosure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive variable frequency drives for compliance with requirements, installation tolerances, and other conditions affecting performance.

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

3.2 APPLICATIONS

A. Select features of each variable frequency drive to coordinate with ratings and characteristics of motor; required control sequence; duty cycle of motor, drive, and load.

B. Select horsepower rating of variable frequency drives to suit the motor controlled.

3.3 VARIABLE FREQUENCY DRIVE INSTALLATION

A. Install variable frequency drives according to manufacturers written instructions.

B. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components, including the pretesting and adjustment of variable frequency drives.

C. Location: Locate controllers within sight of motors controlled, unless otherwise indicated.

D. For variable frequency drives at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For variable frequency drives not at walls, provide freestanding racks conforming to Division 16 Section "Basic Electrical Materials and Methods."

1. Comply with mounting and anchoring requirements specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

E. Install freestanding equipment on concrete housekeeping bases conforming to Division 3 Section "Cast-in-Place Concrete."

1. Comply with mounting and anchoring requirements specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

3.4 CONNECTIONS

A. Tighten connectors, terminals, bus joints, and mountings. Tighten field-connected connectors and terminals, including screws and bolts, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 CLEANING

A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean variable frequency drives, on completion of installation, according to manufacturer's written instructions.

3.6 FIELD QUALITY CONTROL

A. Perform acceptance tests as follows and include the report in the emergency, operation, and maintenance manuals specified in Division 1 and Division 15 Section "Basic Mechanical Materials and Methods":

1. Run each motor with its variable frequency drive. Demonstrate correct rotation, alignment, and speed at motor design load.
2. Test interlocks and control features for proper operation.

3. Verify that current in each phase is within nameplate rating.
4. Inspect field-assembled components, equipment installation, and electrical connections for compliance with requirements.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain variable frequency drives as specified below:

1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining variable frequency drives.
   a. Conduct a minimum of 4 hours of training in operation and maintenance as specified in Division 1 Section "Contract Closeout." Include training relating to equipment operation and maintenance procedures.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15056

SECTION 15060 - HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes hangers and supports for mechanical system piping and equipment.

B. Related Sections include the following:

1. Division 5 Section "Metal Fabrications" for materials for attaching hangers and supports to building structure.
2. Division 13 Sections on fire-suppression piping for fire-suppression pipe hangers.
3. Division 15 Section "Mechanical Vibration Controls and Seismic Restraints" for vibration isolation and seismic restraint devices.
4. Division 15 Section "Mechanical Vibration and Seismic Controls" for piping spring hanger and support requirements.

1.3 DEFINITIONS

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

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

1.4 PERFORMANCE REQUIREMENTS

A. Design channel support and pipe racks systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

B. Design heavy-duty steel trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

C. Design seismic restraint hangers and supports for piping and equipment.

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

1.5 SUBMITTALS

A. Product Data: For each type of pipe hanger, channel support and rack system component, and thermal-hanger shield insert indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer for multiple piping supports and trapeze hangers. Include design calculations and indicate size and characteristics of components and fabrication details.

C. Welding Certificates: Copies of certificates for welding procedures and operators.

1.6 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for each multiple pipe support, trapeze, and seismic restraint by a qualified professional engineer.

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Pipe Hangers:

a. B-Line Systems, Inc.
b. Carpenter & Patterson, Inc.
c. Grinnell Corp.
d. Globe Pipe Hanger Products, Inc.
e. GS Metals Corp.
f. Michigan Hanger Co., Inc.
g. National Pipe Hanger Corp.
h. PHD Manufacturing, Inc.
i. PHS Industries, Inc.
j. Piping Technology & Products, Inc.

2. Channel Support Systems:

   a. B-Line Systems, Inc.
   b. Grinnell Corp.; Power-Strut Unit.
   c. GS Metals Corp.
   d. Michigan Hanger Co., Inc.; O-Strut Div.
   e. National Pipe Hanger Corp.
   f. Thomas & Betts Corp.
   g. Unistrut Corp.

3. Thermal-Hanger Shield Inserts:

   a. Carpenter & Patterson, Inc.
   b. Michigan Hanger Co., Inc.
   c. PHS Industries, Inc.
   d. Pipe Shields, Inc.

2.2 MANUFACTURED UNITS

A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.

   1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.
   2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.

   1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
   2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

C. Thermal-Hanger Shield Inserts: 100-psi (690-kPa) minimum compressive-strength insulation, encased in sheet metal shield.

   1. Material for Cold Piping: ASTM C 552, Type I cellular glass with vapor barrier.
   2. Material for Hot Piping: ASTM C 552, Type I cellular glass.
   3. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
   4. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.
   5. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.3 MISCELLANEOUS MATERIALS

A. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

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

C. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.

1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
2. Properties: Nonstaining, noncorrosive, and nongaseous.
3. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger requirements are specified in Sections specifying equipment and systems.

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

C. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification 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 3.
2. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 6 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
3. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 4 to NPS 6, from single rod if horizontal movement caused by expansion and contraction might occur.
4. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30 (DN50 to DN750), if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

D. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification 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 (DN20 to DN500).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN20 to DN500), if longer ends are required for riser clamps.

E. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) 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 (49 to 232 deg C) piping installations.

F. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification 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. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
3. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
4. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge. The use of this structural attachment is limited to situations where the height of the piping will not allow for installation of hangers attached to the bottom of the structural steel flange.
5. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
6. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
7. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
8. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
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 (675 kg).
    c. Heavy (MSS Type 33): 3000 lb (1350 kg).

10. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
11. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

G. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification 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 by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, 100-psi (690-kPa) minimum compressive-strength, water-repellent-treated cal-

cium silicate or cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.

H. Spring Hangers and Supports: Refer to Division 15 Section "Mechanical Vibration and Seismic Controls" for piping spring hanger and support requirements.

3.2 HANGER AND SUPPORT INSTALLATION

A. Pipe Hanger and Support 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. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.

1. Field assemble and install according to manufacturer's written instructions.

C. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.

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 D-1.1.

D. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, 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.

E. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

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

G. 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.

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

I. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.

J. 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 B31.9.

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 (DN100) 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 arc of 180 degrees.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN100) 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 (DN8 to DN90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
   b. NPS 4 (DN100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
   c. NPS 5 and NPS 6 (DN125 and DN150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
   d. NPS 8 to NPS 14 (DN200 to DN350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
   e. NPS 16 to NPS 24 (DN400 to DN600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

5. Pipes NPS 8 (DN200) 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 above or to support equipment above floor.

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

3.4 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes 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 Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.6 PAINTING

A. Touching 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 a minimum dry film thickness of 2.0 mils (0.05 mm).

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

END OF SECTION 15060

SECTION 15071 - MECHANICAL VIBRATION AND SEISMIC CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Vibration isolation elements for equipment, piping, and ductwork.
      a. Elastomeric isolation pads.
      b. Elastomeric isolation mounts.
      c. Elastomeric hangers.
      d. Spring hangers.
      e. Spring hangers with vertical-limit stops.
      f. Freestanding spring isolators.
      g. Restrained spring isolators.
      h. Pipe riser resilient supports.
      i. Resilient pipe guides.
   2. Equipment isolation bases and curbs.
      a. Inertia vibration isolation equipment bases.
   3. Seismic restraints for isolated equipment.
      a. Seismic snubbers.
   4. Seismic restraints for non-isolated equipment, piping, and ductwork.
      a. Restraining cables.
   5. Certification of seismic restraint designs and installation supervision.
   6. Certification of seismic attachment of housekeeping pads.

1.3 DEFINITIONS

A. A_v: Effective peak velocity related acceleration coefficient.

1.4 PERFORMANCE REQUIREMENTS

A. A_v: The Effective Peak Velocity-Related Acceleration Coefficient (A_v) shall be 0.10.

B. Component Seismic Coefficient: Refer to the equipment schedule in Part 3 of this Section for the Component Seismic Coefficient for each piece of equipment.

C. Performance Criteria Factor: Refer to the equipment schedule in Part 3 of this Section for the Performance Criteria Factor for each piece of equipment.

D. Attachment Amplification Factor: Refer to the equipment schedule in Part 3 of this Section for the Attachment Amplification Factor for each piece of equipment.

1.5 SUBMITTALS

A. Product Data: Submit the following product data:

1. Data sheets on specific vibration isolators and restraints to be utilized.
2. An itemized list of isolated and non-isolated equipment. Detailed schedules showing isolator and seismic restraint proposed for each piece of equipment, referencing material Drawing number and specified location.
3. Show base construction for equipment; include dimensions, structural member sizes and support point locations.
4. Indicate isolation devices selected with complete dimensional and deflection data.
5. Show all methods of suspension and support for ceiling hung equipment.
6. Detail methods of isolation for ducts and pipes piercing walls and slabs.
7. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Include the following:

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
4. Seismic-Restraint Details: Detail fabrication and attachment of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
5. Submittals for Interlocking Snubbers: Include load deflection curves up to 1/2-inch (13-mm) deflection in x, y, and z planes.

C. Welding certificates.

D. Manufacturer Seismic Qualification Certification: Submit certification that all specified equipment will withstand seismic forces identified in "Performance Requirements" Article above. Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
   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 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.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7.

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. Seismic Snubber Units: Furnish replacement neoprene inserts for all snubbers.

PART 2 - PRODUCTS

2.1 GENERAL

A. All vibration isolation and seismic restraint devices shall be capable of accepting, without failure, one-half "G" external forces and one "G" for life safety equipment.

B. Vibration isolation devices shall maintain the equipment in a captive position and not short circuit isolation during normal operating conditions.

C. Vibration isolation and seismic restraint devices shall have provisions for bolting and/or welding to the structure.

2.2 ELASTOMERIC ISOLATION PADS

A. **(TYPE 1 and TYPE 1R)** – Elastomeric Isolation Pads: Subject to compliance with requirements, provide elastomeric isolation pads by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.
   a. Model: Type SW.

2. Amber Booth Company, Inc.; Houston, Texas.
   a. Model: Type NR.

3. Vibration Mountings and Controls/Korfund; Bloomingdale, New Jersey.
   a. Model: Type Maxi-Flex.

4. Vibration Eliminator Company, Inc.; Long Island City, New York.
   a. Model: Type 200N.

B. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Size pads for a maximum loading of 50 pounds per square inch.
2. Durometer Rating: As required to meet scheduled static deflection at operating equipment weights.
3. Minimum Deflection: Refer to Tables in Part 3 of this Section.
4. Number of Layers: Provide multiple layers separated by 16-gage galvanized steel plates bonded to pads, where required to meet specified performance.
5. Provide metal loading plates on top and bottom, where required for even weight distribution.
6. Provide necessary bolt holes for anchoring to structure. Provide neoprene bushings, and neoprene impregnated duck washers at each bolt hole to prevent short circuiting. (All Type 1R Elastomeric Isolation Pads shall be bolted to the structure to meet seismic compliance.)

2.3 ELASTOMERIC ISOLATION MOUNTS

A. **(TYPE 2)** – Elastomeric Isolation Mounts: Subject to compliance with requirements, provide elastomeric isolation mounts by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.
   a. Model: Type ND.

2. Amber Booth Company, Inc.; Houston, Texas.
   a. Model: Type RVD.

3. Vibration Mountings and Controls/Korfund; Bloomingdale, New Jersey.

a. Model: Type RD.

4. Vibration Eliminator Company, Inc.; Long Island City, New York.
   a. Model: Type 368SD.

B. Elastomeric Mounts: Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Durometer Rating: As required to meet scheduled static deflection at operating equipment weights.

2.4 ELASTOMERIC ISOLATION HANGERS

A. **(TYPE 3)** – Elastomeric Isolation Hangers: Subject to compliance with requirements, provide elastomeric isolation hangers by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.
   a. Model: Type HD.

2. Amber Booth Company, Inc.; Houston, Texas.
   a. Model: Type BRD.

3. Vibration Mountings and Controls/Korfund; Bloomingdale, New Jersey.
   a. Model: Type RHD.

4. Vibration Eliminator Company, Inc.; Long Island City, New York.
   a. Model: Type CD.

B. Elastomeric Hangers: Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

2.5 FREESTANDING SPRING MOUNTED VIBRATION ISOLATORS

A. **(TYPE 4)** - Freestanding Spring Mounted Vibration Isolators: Subject to compliance with requirements, provide freestanding spring mounted vibration isolators by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.
   a. Model: Type SLF.

2. Amber Booth Company, Inc.; Houston, Texas.
   a. Model: Type SW.

3. Vibration Mountings and Controls/Korfund; Bloomingdale, New Jersey.

a. Model: Series AC.

4. Vibration Eliminator Company, Inc.; Long Island City, New York.
   a. Model: Type OSK.

B. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 100 psig (690 kPa).
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 RESTRAINED SPRING MOUNTED VIBRATION ISOLATORS

A. **(TYPE 4R)** - Restrained Spring Mounted Vibration Isolators: Subject to compliance with requirements, provide restrained spring mounted vibration isolators by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.
   a. Model: Type SLR.

2. Amber Booth Company, Inc.; Houston, Texas.
   a. Model: Type CTER.

3. Vibration Mountings and Controls/Korfund; Bloomingdale, New Jersey.
   a. Model: Type AWR.

4. Vibration Eliminator Company, Inc.; Long Island City, New York.
   a. Model: Type KW.

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.7 SPRING ISOLATION HANGERS

A. **(TYPE 5)** - Spring Isolation Hangers: Subject to compliance with requirements, provide spring isolation hangers by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.
   a. Model: Type 30N.

2. Amber Booth Company, Inc.; Houston, Texas.
   a. Model: Type BSRA.

3. Vibration Mountings and Controls/Korfund; Bloomingdale, New Jersey.
   a. Model: Type RSH30A.

4. Vibration Eliminator Company, Inc.; Long Island City, New York.
   a. Model: Type SNRC.

B. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

2.8 SPRING ISOLATION HANGERS WITH VERTICAL STOP

A. **(TYPE 5V)** - Spring Isolation Hangers with Vertical Stop: Subject to compliance with requirements, provide spring isolation hangers with vertical stop by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.
   a. Model: Type PC30N.

2. Amber Booth Company, Inc.; Houston, Texas.
   a. Model: Type PBSRA.

3. Vibration Mountings and Controls/Korfund; Bloomingdale, New Jersey.
   a. Model: Type RSHPR30A.

4. Vibration Eliminator Company, Inc.; Long Island City, New York.
   a. Model: Type PCSR.

B. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.

2.9 PIPE RISER RESILIENT SUPPORT

A. **(TYPE 7)** – Pipe Riser Resilient Supports: Subject to compliance with requirements, provide pipe riser resilient supports by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.
   a. Model: Type ADA.

2. Vibration Mountings and Controls/Korfund; Bloomingdale, New Jersey.
   a. Model: Type MDPA.

3. Vibration Eliminator Company, Inc.; Long Island City, New York.
   a. Model: Type VERA.

B. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick, 60-durometer neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions.

2.10 RESILIENT PIPE GUIDES

A. **(TYPE 8)** – Resilient Pipe Guides: Subject to compliance with requirements, provide resilient pipe guides by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.
   a. Model: Type VSG.

2. Amber Booth Company, Inc.; Houston, Texas.
   a. Model: Type LPR.

3. Vibration Mountings and Controls/Korfund; Bloomingdale, New Jersey.
   a. Model: Type RPG.

4. Vibration Eliminator Company, Inc.; Long Island City, New York.
   a. Model: Type VERG.

B. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick, 60-durometer neoprene. Factory set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.11 STEEL EQUIPMENT BASES

A. **(TYPE 10L)** – Lightweight Steel Equipment Bases: Subject to compliance with requirements, provide lightweight steel equipment bases by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.
   a. Model: Type M.

2. Amber Booth Company, Inc.; Houston, Texas.
   a. Model: Type SFB.

3. Vibration Mountings and Controls/Korfund; Bloomingdale, New Jersey.
   a. Model: Type SCA.

4. Vibration Eliminator Company, Inc.; Long Island City, New York.
   a. Model: Type S Base.

B. Steel Base: Factory-fabricated, steel bases.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Perimeter steel members shall be adequately sized to prevent distortion and misalignment of the drive and shall limit the deflection of the beam on the drive side to 0.05" due to starting torque.

2.12 INERTIA BASES

A. **(TYPE 11)** – Inertia Bases: Subject to compliance with requirements, provide inertia bases by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.
   a. Model: Type K.

2. Amber Booth Company, Inc.; Houston, Texas.
   a. Model: Type CPF.

3. Vibration Mountings and Controls/Korfund; Bloomingdale, New Jersey.
   a. Model: Type WPF.

4. Vibration Eliminator Company, Inc.; Long Island City, New York.
   a. Model: Type SN.

B. Inertia Base: Factory-fabricated, welded, structural-steel bases ready for field-applied, cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate a minimum 4" overlap of the supported equipment.
3. Perimeter steel members shall have a minimum depth of 1/12 of the longest span, but not less than 6" deep and not greater than 14" deep. Provide concrete reinforcement bars or angles welded on 6" centers in both directions. Reinforcement layer shall be placed 1-1/2" from the bottom of the base. Provide a second layer of reinforcement 1-1/2" from the top of the base for all bases larger than 120" in any direction.
4. Support Brackets: Factory-welded steel angles on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
5. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.13 SEISMIC-RESTRAINT DEVICES

A. Seismic Restraint Devices: Subject to compliance with requirements, provide seismic restraint devices by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.

2. Amber Booth Company, Inc.; Houston, Texas.

3. Vibration Mountings and Controls/Korfund; Bloomingdale, New Jersey.

4. Vibration Eliminator Company, Inc.; Long Island City, New York.

B. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer of 50, plus or minus 5, with a flat washer face.

C. Seismic Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer of 50, plus or minus 5.

D. Restraining Cables: Galvanized steel aircraft cables with end connections made of steel assemblies that swivel to final installation angle and utilize two clamping bolts for cable engagement.

E. Anchor Bolts: Seismic-rated, drill-in, and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488/E 488M.

2.14 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be electrogalvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 INSTALLATION

A. Install roof curbs, equipment supports, and roof penetrations as specified in Division 7.

B. Install thrust limits at centerline of thrust, symmetrical on either side of equipment.

C. Install seismic snubbers on isolated equipment. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

D. Install restraining cables at each trapeze and individual pipe hanger. At trapeze anchor locations, shackle piping to trapeze. Install cables so they do not bend across sharp edges of adjacent equipment or building structure.

E. Install steel angles or channel, sized to prevent buckling, clamped with ductile-iron clamps to hanger rods for trapeze and individual pipe hangers. At trapeze anchor locations, shackle piping to trapeze. Requirements apply equally to hanging equipment. Do not weld angles to rods.

F. Install resilient bolt isolation washers on equipment anchor bolts.

3.3 EQUIPMENT BASES

A. Fill concrete inertia bases, after installing base frame, with **3000-psi (20.7-MPa)** concrete; trowel to a smooth finish.

1. Cast-in-place concrete materials and placement requirements are specified in Division 3.

B. Concrete Bases: Anchor equipment to concrete base according to supported equipment manufacturer's written instructions for seismic codes at Project site.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
2. Install epoxy-coated anchor bolts for supported equipment 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.
5. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
6. Cast-in-place concrete materials and placement requirements are specified in Division 3.

3.4 FIELD QUALITY CONTROL

A. Upon completion of installation of all vibration isolation devices, the local representative shall inspect the completed project and certify in writing to the contractor that all systems are installed properly, or require correction. The contractor shall submit a report to the Architect, including the representative's report. Certifying correctness of the installation or detailing corrective work to be done.

B. Testing: Perform the following field quality-control testing:

1. Isolator seismic-restraint clearance.
2. Isolator deflection.
3. Snubber minimum clearances.

3.5 ADJUSTING

A. Adjust isolators after piping systems have been filled and equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop.

D. Adjust active height of spring isolators.

E. Adjust snubbers according to manufacturer's written recommendations.

F. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

G. Torque anchor bolts according to equipment manufacturer's written recommendations to resist seismic forces.

3.6 CLEANING

A. After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt, and debris.

3.7 VIBRATION ISOLATOR AND SEISMIC-RESTRAINT SCHEDULE

A. Supported or Suspended Equipment Tables:

TABLE A
SEISMIC RESTRAINT SCHEDULE FOR NON-ISOLATED EQUIPMENT LOCATED ON GRADE AND ABOVE GRADE

EQUIPMENT	COMPONENT SEISMIC COEFFICIENT	PERFORMANCE CRITERIA FACTOR	ATTACHMENT AMPLIFICATION FACTOR	NOTES
Custom Air Handling Units				
Floor Mounted (Internally Isolated)	2.0	1.5	1.0	
Packaged Rooftop Air Conditioners				
Roof Curb Mounted (Internally Isolated)	2.0	1.5	1.0	Note 1,4
Heat Exchangers				
Shell and Tube	2.0	1.5	1.0	
Unfired Steam Generators	2.0	1.5	1.0	
Tanks				
Air Separators-Floor Mounted	2.0	1.5	1.0	
Expansion Tanks-Floor Mounted	2.0	1.5	1.0	
Flash Tanks-Floor Mounted	2.0	1.5	1.0	
Blow-down Separators-Floor Mounted	2.0	1.5	1.0	
Dom. Hot Water Tanks/Heaters-Flr. Mtd.	2.0	1.5	1.0	
Variable Frequency Drives				
Wall and Floor Mounted	2.0	1.5	1.0	
ATC Control Panels				
Wall Mounted	2.0	1.5	1.0	
Piping Systems				
Steam Piping (All Pressures)	2.0	1.5	1.0	
Steam Condensate (All Press and Temps)	2.0	1.5	1.0	
Heating Hot Water Piping (All Temps)	2.0	1.5	1.0	Note 2
Fire Suppression Piping	2.0	1.5	1.0	
Compressed Gas Piping (>40psig)	2.0	1.5	1.0	
Other Piping Systems	0.67	1.5	1.0	
HVAC Ductwork				
Ducts >6 sq ft Cross Sectional Area	0.67	1.5	1.0	Note 3

NOTES (Table A):

1. Mount packaged rooftop air conditioners on factory furnished roof curbs. Secure to roof curb in accordance with this Section.
2. Provide vibration isolation devices and seismic restraints on piping connected to vibration producing devices in accordance with Table D.
3. Provide vibration isolation devices and seismic restraints on high-pressure ductwork connected to vibration producing devices in accordance with Table D.
4. Provide restraining cables anchored to equipment supports and structure.

TABLE B
VIBRATION ISOLATOR AND SEISMIC RESTRAINT SCHEDULE
(EQUIPMENT LOCATED ON GRADE and FLOOR OR ROOF MOUNTED)

EQUIPMENT	HORSEPOWER and OTHER	RPM	BASE TYPE	ISOLATOR TYPE	MINIMUM DEFLECTION	COMPONENT SEISMIC COEFFICIENT	PERFORMANCE CRITERIA FACTOR	ATTACHMENT AMPLIFICATION FACTOR	NOTES
Condensate Pumps									
Floor Mounted **Air Compressors (ATC)**	All	All	--	1R	0.75"	2.0	1.5	1.0	1
Tank Mounted	≤10Hp	All	--	4	0.75"	2.0	1.5	1.0	1,2,3
Tank Mounted	≥15Hp	All	11	4	0.75"	2.0	1.5	1.0	1,2,3
Medical Vacuum Pumps									
Packaged	All	All	--	1R	0.25"	2.0	1.5	1.0	1,3
Packaged Air Cond Units									
Ceiling mounted (Interior)	All	All	--	5	0.25"	2.0	1.5	1.0	3,4

NOTES (Table B):

1. Equipment base or isolator bolted to concrete base. Install resilient bolt isolation washers on equipment anchor bolts.
2. Provide seismic snubbers bolted to concrete base. Install resilient bolt isolation washers on seismic snubber anchor bolts.
3. Coordinate vibration isolators with packaged equipment provided under other Sections.
4. Attached to structure overhead.

TABLE C
VIBRATION ISOLATOR AND SEISMIC RESTRAINT SCHEDULE
(EQUIPMENT LOCATED ABOVE GRADE and FLOOR OR ROOF MOUNTED)

EQUIPMENT	HORSEPOWER and OTHER	RPM	BASE TYPE	ISOLATOR TYPE	MINIMUM DEFLECTION	COMPONENT SEISMIC COEFFICIENT	PERFORMANCE CRITERIA FACTOR	ATTACHMENT AMPLIFICATION FACTOR	NOTES
Pumps									
End Suction	All	All	11	4	1.75"	2.0	1.5	1.0	1,2

EQUIPMENT	HORSEPOWER and OTHER	RPM	BASE TYPE	ISOLATOR TYPE	MINIMUM DEFLECTION	COMPONENT SEISMIC COEFFICIENT	PERFORMANCE CRITERIA FACTOR	ATTACHMENT AMPLIFICATION FACTOR	NOTES
Condensate Pumps									
Floor Mounted	All	All	--	1R	0.75"	2.0	1.5	1.0	7
Air Compressors									
Tank Mounted	≤10Hp	All	--	4	1.75"	2.0	1.5	1.0	1,2,4
Tank Mounted	≥15Hp	All	--	4	1.75"	2.0	1.5	1.0	1,2,4
Medical Vacuum Pumps									
Packaged	All	All	--	1R	0.25"	2.0	1.5	1.0	1,4
Centrifugal Fans									
<22" Diameter	≤3.0"S.P.wg	All	--	5	0.25"	2.0	1.5	1.0	3,6
Condensing Units (Dry-coolers)									
Rail Mounted (Exterior)	All	All	--	1R	0.25"	2.0	1.5	1.0	1,4
Vertical Pipe Risers									
Pipe Riser Supports	Note 6	Note 6	--	7	--	2.0	1.5	1.0	5
Pipe Riser Guides	Note 6	Note 6	--	8	--	2.0	1.5	1.0	5

NOTES (Table C):

1. Equipment base or isolator bolted to concrete base. Install resilient bolt isolation washers on equipment anchor bolts.
2. Provide seismic snubbers bolted to concrete base. Install resilient bolt isolation washers on seismic snubber anchor bolts.
3. Equipment bolted to support structure. Install resilient bolt isolation washers on equipment anchor bolts.
4. Coordinate vibration isolators with packaged equipment provided under other Sections.
5. On all heating hot water, steam (all pressures), and steam condensate pipe risers 3" and larger that penetrate 3 floors or more, anchor piping at the midpoint with Type 7 - Pipe Riser Resilient Supports and provide Type 8 – Resilient Pipe Guides within 12-15 feet in both directions from pipe anchor. Provide Type 4 – Freestanding Spring Vibration Isolators at each floor with a minimum deflection of 0.75" except in those expansion locations where additional deflection is required to limit load changes to ±25% of the initial load. Provide submittals in accordance with Part 1 of these specifications. Provide submittals showing riser diagram and calculations showing anticipated expansion and contraction at each support point, initial and final loads on the building structure, springdeflection changes and seismic loads. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist in the proposed design.
6. Mount packaged rooftop air conditioners on factory furnished roof curbs. Secure to roof curb in accordance with this Section.

7. Equipment base attached to inertia base.

TABLE D
VIBRATION ISOLATOR AND SEISMIC RESTRAINT SCHEDULE
(EQUIPMENT LOCATED ABOVE GRADE and SUSPENDED)

EQUIPMENT	HORSEPOWER and OTHER	RPM	BASE TYPE	ISOLATOR TYPE	MINIMUM DEFLECTION	COMPONENT SEISMIC COEFFICIENT	PERFORMANCE CRITERIA FACTOR	ATTACHMENT AMPLIFICATION FACTOR	NOTES
Inline Cent & Axial Fans									
<22" Diameter	≤3.0"S.P.wg	All	--	5	1.50"	2.0	1.5	1.0	1
<22" Diameter	≥3.1"S.P.wg	All	--	5	1.50"	2.0	1.5	1.0	1,2
>24" Diameter	≤50Hp	<300	--	5	2.50"	2.0	1.5	1.0	1,2
>24" Diameter	≤50Hp	300-500	--	5	1.75"	2.0	1.5	1.0	1,2
>24" Diameter	≤50Hp	>500	--	5	1.00"	2.0	1.5	1.0	1,2
>24" Diameter	≥60Hp	<300	--	5V	3.50"	2.0	1.5	1.0	1,2
>24" Diameter	≥60Hp	300-500	--	5V	2.50"	2.0	1.5	1.0	1,2
>24" Diameter	≥60Hp	>500	--	5V	1.75"	2.0	1.5	1.0	1,2
Small Rotating Equip									
Small Fan Coil Units	≤600 CFM	All	--	3	0.75"	2.0	1.5	1.0	1
Large Fan Coil Units	≥601 CFM	All	--	5	0.75"	2.0	1.5	1.0	1
Small Inline Fans	≤600 CFM	All	--	3	0.75"	2.0	1.5	1.0	1
Cabinet Unit Heaters	All	All	--	3	0.75"	2.0	1.5	1.0	1
Propeller Unit Heaters	All	All	--	3	0.75"	2.0	1.5	1.0	1
Heating Hot Water Piping									
(1" to 3") Suspended	Note 3	Note 3	--	3	Note 3	2.0	1.5	1.0	3
(4" to 8") Suspended	Note 3	Note 3	--	5	Note 3	2.0	1.5	1.0	3
(10"&Larger) Suspended	Note 3	Note 3	--	5V	Note 3	2.0	1.5	1.0	3

NOTES (Table D):

1. Provide restraining cables anchored to equipment supports and structure.
2. Provide vibration isolators listed in the table on each pipe hanger for heating hot water piping for a distance of 50 pipe diameters in both directions from circulating pumps or a minimum of three pipe hangers, whichever is greater. Deflection of isolators shall be equal to or greater than the static deflection of the vibration isolators provided for the connected pumps. Provide metal heat shield or thermal isolators on all neoprene isolators.
3. Provide vibration isolators listed in the table on hot water for all hangers located 50 feet either side of base mounted hot water pumps. Deflection of isolators shall be equal to or

greater than the static deflection of the vibration isolators provided for the connected pumps.

END OF SECTION 15071

SECTION 15075 - MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following mechanical identification materials and their installation:

1. Equipment nameplates.
2. Equipment markers.
3. Equipment signs.
4. Access panel and door markers.
5. Pipe markers.
6. Duct markers.
7. Valve tags.
8. Valve schedules.
9. Warning tags.

1.3 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. Valve numbering scheme coordinated with the Owners valve numbering scheme.

D. Valve Schedules: For each piping system.

1. Valve schedule shall indicate the valve number, piping system, system abbreviation as shown on tag, room or space location of valve, and variations for identification.
2. Tabulate valve schedules to indicate the location of all valves by room name and number as identified on the architectural floor plans.
3. Indicate areas, floors, or specific rooms controlled by each.
4. Mark valves intended for emergency shutoff and similar special uses.
5. In addition to mounted copies, furnish copies for maintenance manuals specified in Division 1 and Division 15 Section 15050 "Basic Mechanical Materials and Methods".

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

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 location of access panels and doors.

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

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.

1. Data:

a. Manufacturer, product name, model number, and serial number.
b. Capacity, operating and power characteristics, and essential data.
c. Labels of tested compliances.

2. Location: Accessible and visible.
3. Fasteners: As required to mount on equipment.

B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.

1. Terminology: Match schedules as closely as possible.
2. Data:

a. Name and plan number.
b. Equipment service.
c. Design capacity.
d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.

3. Size: 2-1/2 by 4 inches (64 by 100 mm) for control devices, dampers, and valves; 4-1/2 by 6 inches (115 by 150 mm) for equipment.

C. Equipment Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.

1. Data: Instructions for operation of equipment and for safety procedures.
2. Engraving: Manufacturer's standard letter style, of sizes and with terms to match equipment identification.
3. Thickness: 1/8 inch (3.2 mm), unless otherwise indicated.
4. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

D. Access Panel and Door Markers: 1/16-inch- (1.6-mm-) thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch (3.2-mm) center hole for attachment.

1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.2 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.

1. Colors: Comply with ASME A13.1, unless otherwise indicated.
2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
3. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Full-band pipe markers extending 360 degrees around pipe at each location.
4. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

B. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.

C. Plastic Tape: Continuously printed, vinyl tape at least 3 mils (0.08 mm) thick with pressure-sensitive, permanent-type, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

2.3 DUCT IDENTIFICATION DEVICES

A. Duct Markers: Engraved, color-coded laminated plastic. Include direction and quantity of air-flow and duct service (such as supply, return, and exhaust). Include contact-type, permanent adhesive.

2.4 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers, with numbering scheme approved by Architect. Provide 5/32-inch (4-mm) hole for fastener.

1. Material: 0.032-inch- (0.8-mm-) thick brass or 3/32-inch- (2.4-mm-) thick laminated plastic with 2 black surfaces and white inner layer.
2. Valve-Tag Fasteners: Brass wire-link or beaded chain; or S-hook.

2.5 VALVE SCHEDULES

A. Valve Schedules: For each piping system, on standard-size 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-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
2. Frame: Extruded aluminum.
3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

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: Approximately 4 by 7 inches (100 by 178 mm).
2. Fasteners: Brass 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 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 15 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:

1. Pumps, compressors, condensers, and similar motor-driven units.
2. Heat exchangers, coils, and similar equipment.
3. Fans, blowers, primary balancing dampers, and mixing boxes.
4. Packaged HVAC central-station and zone-type units.

B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.

1. Letter Size: Minimum 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:

    a. Main control and operating valves, including safety devices.
    b. Fire department hose valves and hose stations.
    c. Meters, gages, thermometers, and similar units.
    d. Pumps, compressors, condensers, and similar motor-driven units.
    e. Heat exchangers, coils, and similar equipment.
    f. Fans, blowers, primary balancing dampers, and mixing boxes.
    g. Packaged HVAC central-station and zone-type units.
    h. Tanks and pressure vessels.
    i. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.

C. Install equipment signs with screws or permanent adhesive on or near each major item of mechanical equipment. Locate signs where accessible and visible.

1. Identify mechanical equipment with equipment markers in the following color codes:

    a. Green: For cooling equipment and components.
    b. Yellow: For heating equipment and components.

c. Orange: For combination cooling and heating equipment and components.

2. Letter Size: Minimum 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
3. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
4. Include signs for the following general categories of equipment:

   a. Main control and operating valves, including safety devices.
   b. Pumps, compressors, condensers, and similar motor-driven units.
   c. Heat exchangers, coils, and similar equipment.
   d. Fans, blowers, primary balancing dampers, and mixing boxes.
   e. Packaged HVAC central-station and zone-type units.
   f. Tanks and pressure vessels.
   g. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.

D. Install access panel markers with screws on equipment access panels.

3.3 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.
   1. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, [**at least 3/4 inch (19 mm)**] [**1-1/2 inches (38 mm)**] wide, lapped at least 1-1/2 inches (38 mm) at both ends of pipe marker, and covering full circumference of pipe.
   2. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches (38 mm) wide, lapped at least 3 inches (75 mm) at both ends of pipe marker, and covering full circumference of pipe.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed and above removable acoustical ceiling 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 nonaccessible 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 10 feet in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings where walls extend to the underside of structure, install pipe markers in each room.

3.4 DUCT IDENTIFICATION

A. Install duct markers with permanent adhesive on air ducts in the following color codes:

1. Green: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Blue: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
4. ASME A13.1 Colors and Designs: For hazardous material exhaust.
5. Letter Size: Minimum 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

B. Locate markers near points where ducts enter into concealed spaces and at maximum intervals of 25 feet (15 m) in each space where ducts are exposed or concealed by removable ceiling system.

1. On ductwork above removable acoustical ceilings where walls extend to the underside of structure, install duct markers in each room.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; plumbing fixture supply stops; faucets; and convenience and lawn-watering hose connections. 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 tables:

HVAC Hydronic Systems Valve Tag Application Table

HVAC HYDRONIC SYSTEMS	TAG SIZE	TAG SHAPE	TAG COLOR	LETTER COLOR	SYSTEM ID
Chilled Water	2"	Round	Green	White	CHW
Hot Water	1-1/2"	Square	Yellow	Black	HW
Variable Temperature Hot Water	1-1/2"	Square	Yellow	Black	VHW
Non-Potable Cold Wtr Make-up	2"	Round	Green	Black	NPCW

HVAC Steam and Condensate Systems Valve Tag Application Table

HVAC STEAM SYSTEMS	TAG SIZE	TAG SHAPE	TAG COLOR	LETTER COLOR	SYSTEM ID

HVAC STEAM SYSTEMS	TAG SIZE	TAG SHAPE	TAG COLOR	LETTER COLOR	SYSTEM ID
High Pressure Steam	2"	Square	Red	White	HPS
High Pressure Condensate	2"	Square	Red	White	HPR
Medium Pressure Steam	2"	Square	Red	White	MPS
Medium Pressure Condensate	2"	Square	Red	White	MPR
Low Pressure Process Steam	2"	Square	Red	White	LPSH
Low Press Process Condensate	2"	Square	Red	White	LPRH
Low Pressure Steam	2"	Square	Red	White	LPS
Low Pressure Condensate	2"	Square	Red	White	LPR
Pumped Condensate Discharge	2"	Square	Red	White	PD

Plumbing System Valve Tag Application Table

PLUMBING SYSTEMS	TAG SIZE	TAG SHAPE	TAG COLOR	LETTER COLOR	SYSTEM ID
Domestic Cold Water	2"	Round	Green	White	CW
Domestic Hot Water	2"	Square	Yellow	White	HW
Domestic Hot Water Circulation	2"	Square	Yellow	Black	HWC
Gas	1-1/2"	Square	Black	White	LPG
Steam	2"	Square	Red	White	LPS

Fire Protection System Valve Tag Application Table

FIRE PROTECTION SYSTEMS	TAG SIZE	TAG SHAPE	TAG COLOR	LETTER COLOR	SYSTEM ID
Fire Line Piping	2"	Round	Red	White	FL
Sprinkler	2"	Round	Red	White	SP

Medical Gas System Valve Tag Application Table

MEDICAL GAS SYSTEMS	TAG SIZE	TAG SHAPE	TAG COLOR	LETTER COLOR	SYSTEM ID
Oxygen	1-1/2"	Round	Green	Black	OX
Medical Air	1-1/2"	Round	Yellow	Black	MA
Nitrous Oxide	1-1/2"	Round	Blue	Black	N2O
Nitrogen	1-1/2"	Round	Green	Black	N2
Medical Vacuum	1-1/2"	Round	White	Black	MV

3.6 VALVE-SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location in each major equipment room.

3.7 WARNING-TAG INSTALLATION

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

3.8 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.9 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION 15075

SECTION 15081 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes semirigid and flexible duct, and plenum insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

B. Related Sections include the following:

1. Division 7 Section "Firestopping" for firestopping materials and requirements for penetrations through fire and smoke barriers.
2. Division 15 Section "Equipment Insulation" for insulation materials and application for pumps, tanks, hydronic specialties, and other equipment.
3. Division 15 Section "Pipe Insulation" for insulation for piping systems.

1.3 SUBMITTALS

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

B. Shop Drawings: Show fabrication and installation details for the following:

1. Removable insulation sections at access panels.
2. Application of field-applied jackets.
3. Applications at linkages for control devices.

C. Samples: For each type of insulation and field-applied jacket. Identify each Sample, describing product and intended use. Submit 12-inch- (300-mm-) square sections of each sample material.

D. Material Test Reports: From a qualified testing agency acceptable to 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.

E. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.

1.4 QUALITY ASSURANCE

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

B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.
2. Insulation Installed Outdoors: Flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups according to the following requirements, using materials indicated for the completed Work:

1. Include the following mockups:

   a. One 10-foot (3-m) section of rectangular straight duct.
   b. One 90-degree square elbow and one 90-degree radius elbow.
   c. One branch takeoff.
   d. One transition fitting.
   e. Four support hangers.

2. Build mockups with cutaway sections to allow observation of application details for insulation materials, mastics, attachments, and jackets.
3. Build mockups in the location indicated or, if not indicated, as directed by Architect.
4. Notify Architect seven days in advance of dates and times when mockups will be constructed.
5. Obtain Architect's approval of mockups before starting insulation application.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate clearance requirements with duct Installer for insulation application.

1.7 SCHEDULING

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Mineral-Fiber Insulation:

a. CertainTeed Manson.
b. Knauf FiberGlass GmbH.
c. Owens-Corning Fiberglas Corp.
d. Schuller International, Inc.

2.2 INSULATION MATERIALS

A. Mineral-Fiber Blanket Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.

2.3 FIELD-APPLIED JACKETS

A. Aluminum Jacket: Sheets manufactured from aluminum alloy complying with ASTM B 209 (ASTM B 209M), and having an integrally bonded moisture barrier over entire surface in contact with insulation. Metal thickness and corrugation dimensions are scheduled at the end of this Section.

1. Finish: As indicated in the Insulation Application Tables and associated notes located at the end of this Section of the specifications.
2. Moisture Barrier: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.

2.4 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz./sq. yd. (270 g/sq. m).

1. Tape Width: 4 inches (100 mm).

B. Bands: 3/4 inch (19 mm) wide, in one of the following materials compatible with jacket:

1. Aluminum: 0.007 inch (0.18 mm) thick.

C. Wire: 0.080-inch (2.0-mm), nickel-copper alloy; 0.062-inch (1.6-mm), soft-annealed, stainless steel; or 0.062-inch (1.6-mm), soft-annealed, galvanized steel.

D. Adhesive-Attached Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

1. Adhesive: Recommended by the anchor pin manufacturer as appropriate for surface temperatures of ducts, plenums, and breechings; and to achieve a holding capacity of 100 lb (45 kg) for direct pull perpendicular to the adhered surface.

2.5 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

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.

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.

3.3 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each duct system.

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

D. Apply multiple layers of insulation with longitudinal and end seams staggered.

E. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

F. Keep insulation materials dry during application and finishing.

G. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

H. Apply insulation with the least number of joints practical.

I. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

J. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.

K. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

L. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.
3. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to duct flanges and fittings.

M. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.

N. Install vapor-retarder mastic on all ducts and plenums.

1. Ducts with Vapor Retarders: Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.

O. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.

1. Seal penetrations with vapor-retarder mastic.
2. Apply insulation for exterior applications tightly joined to interior insulation ends.

3. Seal insulation to roof flashing with vapor-retarder mastic.

P. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.

Q. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.

R. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.

1. For insulation indicated to have vapor retarders, taper termination and seal insulation ends with vapor-retarder mastic.

3.4 MINERAL-FIBER INSULATION APPLICATION

A. Blanket Applications for Ducts and Plenums: Secure blanket insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, 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 anchor pins and speed washers on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches (450 mm) and smaller, along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
    b. On duct sides with dimensions larger than 18 inches (450 mm). Space 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Apply additional pins and clips to hold insulation tightly against surface at cross bracing.
    c. Anchor pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.

4. Impale insulation over anchors and attach speed washers.
5. 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.
6. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch (13-mm) staples, 1 inch (25 mm) o.c., and cover with pressure-sensitive tape having same facing as insulation.
7. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. Secure with steel band at end joints and spaced a maximum of 18 inches (450 mm) o.c.

8. Apply insulation on rectangular duct elbows and transitions with a full insulation segment for each surface. Apply insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
9. Insulate duct stiffeners, hangers, and flanges that protrude beyond the insulation surface with 6-inch- (150-mm-) wide strips of the same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 6 inches (150 mm) o.c.
10. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.

3.5 FIELD-APPLIED JACKET APPLICATION

A. Apply metal jacket where indicated, with 2-inch (50-mm) 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 aluminum bands 12 inches (300 mm) o.c. and at end joints.

3.6 DUCT SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are specified in the application schedules in Part 3 of this Section.

B. Insulate each of the duct and plenum systems specified in the application schedules in Part 3 of this Section.

C. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner.
3. Double wall insulated outside air, relief air, and exhaust air plena.
4. Factory-insulated flexible ducts.
5. Factory-insulated plenums, casings, terminal boxes, and filter boxes and sections.
6. Flexible connectors.
7. Vibration-control devices.
8. Testing agency labels and stamps.
9. Nameplates and data plates.
10. Access panels and doors in air-distribution systems.

3.7 INDOOR DUCT AND PLENUM APPLICATION SCHEDULE

A. Interior Concealed Duct and Plenum Insulation Application Schedule (-10°F to 100°F): Unless otherwise indicated, insulate the following interior concealed duct systems according to the Interior Concealed Duct and Plenum Insulation Application Schedule:

1. Single wall rectangular and round supply air duct systems (all pressures).
2. Outside air plenums and ductwork carrying outside air to air handling units, supply fans, and ventilating units.
3. Exhaust and outside air plena and ductwork a minimum of 10 feet from roof opening for roof mounted exhaust fans and outside air intakes.
4. Exhaust air, relief air, and outside air plena and ductwork up to automatic control dampers.

Interior Concealed Duct and Plenum Insulation Application Schedule (50°F to 95°F)

MATERIAL	FORM	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD- APPLIED JACKET
Mineral Fiber	Blanket	1½"	Yes	None

B. Interior Exposed Duct and Plenum Insulation Application Schedule (-10°F to 100°F): Unless otherwise indicated, insulate the following interior exposed duct systems according to the Interior Exposed Duct and Plenum Insulation Application Schedule:

1. Single wall rectangular and round supply air duct systems (all pressures).
2. Outside air plenums and ductwork carrying outside air to air handling units, supply fans, and ventilating units.
3. Exhaust and outside air plena and ductwork a minimum of 10 feet from roof opening for roof mounted exhaust fans and outside air intakes.
4. Exhaust air, relief air, and outside air plena and ductwork up to automatic control dampers.

Interior Exposed Duct and Plenum Insulation Application Schedule (-10°F to 100°F)

MATERIAL	FORM	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
Mineral fiber	Blanket	1½"	Yes	None

3.8 EXTERIOR DUCT AND PLENUM APPLICATION SCHEDULE

A. Exterior Exposed Rectangular Duct Insulation Application Schedule (50°F to 95°F): Unless otherwise indicated, insulate the following exterior exposed rectangular duct systems according to the Exterior Exposed Rectangular Duct Insulation Application Schedule:

1. Supply air rectangular duct systems (all pressures).
2. Return air rectangular duct systems (all pressures).

Exterior Exposed Rectangular Duct Insulation Application Schedule

MATERIAL	FORM	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
Glass fiber	Board (Note 1)	2"	Yes	A-Note 2

NOTE 1: Mineral fiber board installed on exterior rectangular duct applications shall be a minimum 6.0 pound per cubic foot density.
NOTE 2: Provide an aluminum field applied jacket 0.040 inch thick with stucco-embossed finish.

END OF SECTION 15081

SECTION 15082 - EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes blanket, board, and block insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

B. Related Sections include the following:

1. Division 15 Section "Duct Insulation" for insulation materials and application for ducts and plenums.
2. Division 15 Section "Pipe Insulation" for insulation for piping systems.

1.3 SUBMITTALS

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

B. Shop Drawings: Show fabrication and installation details for the following:

1. Field application for each equipment type.
2. Removable insulation sections at access panels.
3. Application of field-applied jackets.
4. Special shapes for cellular-glass insulation.

C. Samples: For each type of insulation and field-applied jacket. Identify each Sample, describing product and intended use. Submit 12-inch- (300-mm-) square sections of each sample material.

1. Manufacturer's Color Charts: Show the full range of colors available for each type of field-applied finish material indicated.

D. Material Test Reports: From a qualified testing agency acceptable to 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.

E. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.

1.4 QUALITY ASSURANCE

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

B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.
2. Insulation Installed Outdoors: Flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups according to the following requirements, using materials indicated for the completed Work:

1. Include the following mockups:

   a. One heat exchanger.
   b. One small tank or vessel.
   c. One steam condensate pump.

2. Build mockups with cutaway sections to allow observation of application details for insulation materials, mastics, attachments, and jackets.
3. Build mockups in the location indicated or, if not indicated, as directed by Architect.
4. Notify Architect seven days in advance of dates and times when mockups will be constructed.
5. Obtain Architect's approval of mockups before starting insulation application.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate clearance requirements with equipment Installer for insulation application.

B. Schedule insulation application after testing of piping and duct systems.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Mineral-Fiber Insulation:

a. CertainTeed Manson.
b. Knauf FiberGlass GmbH.
c. Owens-Corning Fiberglas Corp.
d. Schuller International, Inc.

2.2 INSULATION MATERIALS

A. Mineral-Fiber Board Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.

2.3 FIELD-APPLIED JACKETS

A. General: ASTM C 921, Type 1, unless otherwise indicated.

B. Aluminum Jacket: Deep corrugated sheets manufactured from aluminum alloy complying with ASTM B 209 (ASTM B 209M), and having an integrally bonded moisture barrier over entire surface in contact with insulation. Metal thickness and corrugation dimensions are scheduled at the end of this Section.

1. Finish: As indicated in the Insulation Application Tables and associated notes located at the end of this Section of the specifications.
2. Moisture Barrier: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.

2.4 ACCESSORIES AND ATTACHMENTS

A. Bands: 3/4 inch (19 mm) wide, in one of the following materials compatible with jacket:

1. Aluminum: 0.007 inch (0.18 mm) thick.

B. Wire: 0.080-inch (2.0-mm), nickel-copper alloy; 0.062-inch (1.6-mm), soft-annealed, stainless steel; or 0.062-inch (1.6-mm), soft-annealed, galvanized steel.

C. Adhesive-Attached Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

1. Adhesive: Recommended by the anchor pin manufacturer as appropriate for surface temperatures of tanks and breechings; and to achieve a holding capacity of 100 lb (45 kg) for direct pull perpendicular to the adhered surface.

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.

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.

3.3 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of equipment.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each equipment system.

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

D. Apply multiple layers of insulation with longitudinal and end seams staggered.

E. Keep insulation materials dry during application and finishing.

F. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

G. Apply insulation with the least number of joints practical.

H. Apply insulation over fittings and specialties, unless otherwise indicated.

I. Hangers and Anchors: Apply insulation continuously through hangers and around anchor attachments.

J. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Joints and Seams: Cover with tape and vapor barrier as recommended by insulation material manufacturer to maintain vapor seal.

K. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.

L. Removable Insulation: Install insulation on components that require periodic inspecting, cleaning, and repairing for easy removal and replacement without damage to adjacent insulation.

M. Insulate the equipment listed in the equipment insulation application schedules at the end of this Section.

N. Omit insulation from 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 INDOOR TANK AND VESSEL INSULATION APPLICATION

A. Blankets, Board, and Block Applications 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 square foot, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to the equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joint. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesive-attached or self-adhesive anchor pins and speed washers on sides of tanks and vessels as follows:

a. Do not weld anchor pins to ASME-labeled pressure vessels.
b. On tank and vessel, 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
c. Do not overcompress insulation during installation.
d. Cut and miter insulation segments to fit curved sides and dome heads of tanks and vessels.

5. Impale insulation over anchor pins and attach speed washers.
6. 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
7. Secure each layer of insulation with stainless-steel bands.
8. Stagger joints between insulation layers at least 3 inches (75 mm).
9. Apply insulation in removable segments on equipment access doors and other elements that require frequent removal for service.
10. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

3.5 FIELD-APPLIED JACKET APPLICATION

A. Aluminum Jackets: Secure jackets according to jacket manufacturer's written instructions.

3.6 FIELD QUALITY CONTROL

A. Inspection: Perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:

1. Inspect two vessels randomly selected by Architect.

B. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.

C. Reinstall insulation and covers on vessels uncovered for inspection according to these Specifications.

3.7 EQUIPMENT APPLICATIONS

A. Insulation materials and thicknesses are specified in schedules at the end of this Section.

B. Materials and thicknesses for systems listed below are specified in schedules at the end of this Section.

3.8 EQUIPMENT INSULATION APPLICATION SCHEDULES

A. Interior Hot Surface Temperature Equipment (90°F to 200°F): Unless otherwise indicated, insulate the following interior hot surface temperature equipment according to the Interior Hot Surface Temperature Equipment Insulation Application Schedule:

1. Hot water/steam heat exchangers.
2. Hot water air separators.
3. Hot water expansion tanks.

4. Steam flash tanks.
5. Steam condensate pump receivers.
6. Steam blowdown separators.
7. Steam humidifier separators.

Interior Hot Surface Temperature Equipment Insulation Application Schedule (90°F to 200°F)

MATERIAL	FORM	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
Mineral Fiber Board	**Block or board**	**2"**	**No**	**A-Note 1**

NOTE 1: Provide an aluminum field applied jacket 0.040 inch thick with 1-1/4 by 1/4 inch corrugations.

END OF SECTION 15082

SECTION 15083 - PIPE INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

B. Related Sections include the following:

1. Division 7 Section "Firestopping" for firestopping materials and requirements for penetrations through fire and smoke barriers.
2. Division 15 Section "Duct Insulation" for insulation for ducts and plenums.
3. Division 15 Section "Equipment Insulation" for insulation materials and application for pumps, tanks, hydronic specialties, and other equipment.
4. Division 15 Section "Hangers and Supports" for pipe insulation shields and protection saddles.

1.3 SUBMITTALS

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

B. Shop Drawings: Show fabrication and installation details for the following:

1. Application of protective shields, saddles, and inserts at pipe hangers for each type of insulation and hanger.
2. Attachment and covering of heat trace inside insulation.
3. Insulation application at pipe expansion joints for each type of insulation.
4. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Removable insulation at piping specialties and equipment connections.
6. Application of field-applied jackets.

C. Samples: For each type of insulation and jacket. Identify each Sample, describing product and intended use. Submit Samples in the following sizes:

1. Preformed Pipe Insulation Materials: 12 inches (300 mm) long by NPS 2 (DN50).
2. Sheet Form Insulation Materials: 12 inches (300 mm) square.
3. Jacket Materials: 12 inches (300 mm) long by NPS 2 (DN50).
4. Manufacturer's Color Charts: Show the full range of colors available for each type of field-applied finish material indicated.

D. Material Test Reports: From a qualified testing agency acceptable to 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.

E. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.

1.4 QUALITY ASSURANCE

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

B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.
2. Insulation Installed Outdoors: Flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups according to the following requirements, using materials indicated for the completed Work:

1. Include the following mockups:

   a. One 10-foot (3-m) section of NPS 2 (DN50) straight pipe.
   b. One 90-degree elbow.
   c. One tee fitting.
   d. One NPS 2 (DN50) valve.
   e. Four support hangers, including hanger shield and insert.
   f. One strainer with removable portion of insulation.
   g. One reducer.

2. Build mockups with cutaway sections to allow observation of application details for insulation materials, mastics, attachments, and jackets.
3. Build mockups in the location indicated or, if not indicated, as directed by Architect.

4. Notify Architect seven days in advance of dates and times when mockups will be constructed.
5. Obtain Architect's approval of mockups before starting insulation application.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 15 Section "Hangers and Supports."

B. Coordinate clearance requirements with piping Installer for insulation application.

C. Coordinate installation and testing of steam or electric heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after testing piping systems and, where required, after installing and testing heat-trace tape. Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Mineral-Fiber Insulation:

   a. CertainTeed Manson.
   b. Knauf FiberGlass GmbH.
   c. Owens-Corning Fiberglas Corp.
   d. Schuller International, Inc.

2. Cellular-Glass Insulation:

a. Pittsburgh-Corning Corp.

2.2 INSULATION MATERIALS

A. Mineral-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following:

1. Preformed Pipe Insulation: Comply with ASTM C 547, Type 1, with factory-applied, all-purpose, vapor-retarder jacket.
2. Blanket Insulation: Comply with ASTM C 553, Type II, without facing.
3. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:

   a. Class 1, Grade A for bonding glass cloth and tape to unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.
   b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.

4. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.

B. Cellular-Glass Insulation: Inorganic, foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible.

1. Preformed Pipe Insulation, without Jacket: Comply with ASTM C 552, Type II, Class 1.
2. Preformed Pipe Insulation, with Jacket: Comply with ASTM C 552, Type II, Class 2.

C. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2.3 FIELD-APPLIED JACKETS

A. General: ASTM C 921, Type 1, unless otherwise indicated.

B. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.

C. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils (0.5 mm) thick; roll stock ready for shop or field cutting and forming.

1. Adhesive: As recommended by insulation material manufacturer.
2. PVC Jacket Color: White or gray.
3. PVC Jacket Color: Color-code piping jackets based on materials contained within the piping system.

D. Heavy PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 30-mil- (0.75-mm-) thick, high-impact, ultraviolet-resistant PVC.

1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
2. Adhesive: As recommended by insulation material manufacturer.

E. Standard PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil- (0.5-mm-) thick, high-impact, ultraviolet-resistant PVC.

1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
2. Adhesive: As recommended by insulation material manufacturer.

F. Aluminum Jacket: Factory cut and rolled to indicated sizes. Comply with ASTM B 209 (ASTM B 209M), 3003 alloy, H-14 temper.

G. Aluminum Jacket: Aluminum roll stock, ready for shop or field cutting and forming to indicated sizes. Comply with ASTM B 209 (ASTM B 209M), 3003 alloy, H-14 temper.

1. Finish and Thickness: Corrugated finish, 0.010 inch (0.25 mm) thick.
2. Moisture Barrier: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.
3. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.

2.4 ACCESSORIES AND ATTACHMENTS

A. Bands: 3/4 inch (19 mm) wide, in one of the following materials compatible with jacket:

1. Stainless Steel: ASTM A 666, Type 304; 0.020 inch (0.5 mm) thick.
2. Galvanized Steel: 0.005 inch (0.13 mm) thick.
3. Aluminum: 0.007 inch (0.18 mm) thick.
4. Brass: 0.010 inch (0.25 mm) thick.
5. Nickel-Copper Alloy: 0.005 inch (0.13 mm) thick.

B. Wire: 0.080-inch (2.0-mm), nickel-copper alloy; 0.062-inch (1.6-mm), soft-annealed, stainless steel; or 0.062-inch (1.6-mm), soft-annealed, galvanized steel.

2.5 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

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.

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

3.2 PREPARATION

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

3.3 GENERAL APPLICATION REQUIREMENTS

A. Apply 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 piping, including fittings, valves, and specialties.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping system.

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

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

E. Apply 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. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

H. Keep insulation materials dry during application and finishing.

I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

J. Apply insulation with the least number of joints practical.

K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Refer to special instructions for applying insulation over fittings, valves, and specialties.

L. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic.

1. Apply insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12 inches (300 mm) from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.

M. Insulation Terminations: For insulation application where vapor retarders are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.

O. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Circumferential Joints: Cover with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches (100 mm) o.c.
3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches (40 mm). Apply 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 4 inches (100 mm) o.c.

    a. Exception: Do not staple longitudinal laps on insulation having a vapor retarder.

4. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.

P. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.

1. Seal penetrations with vapor-retarder mastic.
2. Apply insulation for exterior applications tightly joined to interior insulation ends.
3. Extend metal jacket of exterior insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
4. Seal metal jacket to roof flashing with vapor-retarder mastic.

Q. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retarder mastic.

R. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.

S. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.

1. Firestopping and fire-resistive joint sealers are specified in Division 7 Section "Firestopping."

T. Floor Penetrations: Apply insulation continuously through floor assembly.

1. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.

3.4 MINERAL-FIBER INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.
2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20 feet (4.5 to 6 m) to form a vapor retarder between pipe insulation segments.
3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the 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. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch (25 mm), and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
3. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets at least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation sections are not available, apply glass-fiber blanket 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 stainer basket without disturbing insulation.
3. Apply insulation to flanges as specified for flange insulation application.
4. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.5 CELLULAR-GLASS INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with wire, tape, or bands without deforming insulation materials.
2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic.
3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of the same thickness as pipe insulation.
4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch (25 mm), and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded sections of insulation are not available, apply mitered sections of cellular-glass insulation. Secure insulation materials with wire, tape, or bands.
3. Cover fittings with aluminum jacket.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded segments of cellular-glass insulation or glass-fiber blanket 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 stainer basket without disturbing insulation.
2. Apply insulation to flanges as specified for flange insulation application.

3.6 FIELD-APPLIED JACKET APPLICATION

A. Foil and Paper Jackets: Apply foil and paper jackets where indicated.

1. Draw jacket material smooth and tight.
2. Apply lap or joint strips with the same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Apply jackets with 1-1/2-inch (40-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-retarder mastic.

B. Apply metal jacket where indicated, with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

3.7 PIPING SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are specified in schedules at the end of this Section.

B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:

1. Flexible connectors.
2. Vibration-control devices.
3. Fire-suppression piping.
4. Drainage piping located in crawl spaces, unless otherwise indicated.
5. Below-grade piping, unless otherwise indicated.

6. Chrome-plated pipes and fittings, unless potential for personnel injury.
7. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.8 FIELD QUALITY CONTROL

A. Inspection: Perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:

1. Inspect fittings and valves randomly selected by Architect.
2. Remove fitting covers from 20 elbows or 1 percent of elbows, whichever is less, for various pipe sizes.
3. Remove fitting covers from 20 valves or 1 percent of valves, whichever is less, for various pipe sizes.

B. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.

C. Reinstall insulation and covers on fittings and valves uncovered for inspection according to these Specifications.

3.9 INSULATION APPLICATION SCHEDULE, GENERAL

A. Refer to insulation application schedules for required insulation materials, vapor retarders, and field-applied jackets.

B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.

3.10 INTERIOR INSULATION APPLICATION SCHEDULE

A. Interior Domestic Cold Water Piping Insulation Application Schedule (35°F to 90°F): Unless otherwise indicated, insulate all interior exposed and concealed domestic cold water piping according to the Interior Domestic Cold Water Piping Insulation Application Schedule:

Interior Domestic Cold Water Piping Insulation Application Schedule (35°F to 90°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
½" to 1¼"	Glass fiber	1"	Yes	None
1½" to 8"	Glass fiber	1½"	Yes	None

B. Interior Domestic Hot Water Piping Insulation Application Schedule (90°F to 180°F): Unless otherwise indicated, insulate the following interior exposed and concealed domestic hot water piping according to the Interior Domestic Hot Water Piping Insulation Application Schedule:

1. Domestic hot water piping.
2. Domestic hot water recirculation piping.

Interior Domestic Hot Water Piping Insulation Application Schedule (90°F to 180°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
½" to 2"	Glass fiber	1"	No	None
2½" to 4"	Glass fiber	1½"	No	None

C. Interior Storm Water Piping Insulation Application Schedule (35°F to 100°F): Unless otherwise indicated, insulate the following interior exposed and concealed storm water piping according to the Interior Storm Water Piping Insulation Application Schedule:

1. Storm water piping.
2. Roof drain bodies.

Interior Storm Water Piping Insulation Application Schedule (35°F to 100°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
All Piping	Glass fiber	1½"	Yes	None

D. Interior Heating Hot Water Piping Insulation Application Schedule (90°F to 200°F): Unless otherwise indicated, insulate the following interior exposed and concealed heating hot water piping according to the Interior Heating Hot Water Piping Insulation Application Schedule:

1. Constant temperature heating hot water systems.
2. Variable temperature heating hot water systems.

Interior Heating Hot Water Piping Insulation Application Schedule (90°F to 200°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
½" to 2" (Note 1)	Glass fiber	½"	No	None
½" to 4"	Glass fiber	1½"	No	None
5" to 10"	Glass fiber	2"	No	None

PIPE SIZES (NPS)	MATERIALS	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
12" to 36"	Glass fiber	2½"	No	None

NOTE 1: Applies to runouts to individual terminal units not exceeding 12 feet in length.

E. Interior Chilled Water Piping Insulation Application Schedule (35°F to 90°F): Unless otherwise indicated, insulate all interior exposed and concealed chilled water piping according to the Interior Chilled Water Piping Insulation Application Schedule:

Interior Chilled Water Piping Insulation Application Schedule (35°F to 90°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
½" to 1¼"	Glass fiber	1"	Yes	None
1½" to 4"	Glass fiber	1½"	Yes	None
5" to 36"	Glass fiber	2"	Yes	None

F. Interior Miscellaneous Piping Insulation Application Schedule (40°F to 90°F): Unless otherwise indicated, insulate the following interior exposed and concealed miscellaneous piping according to the Interior Miscellaneous Piping Insulation Application Schedule:

1. Cold water make-up piping.
2. Piping to and from expansion tanks.
3. Condensate drains from cooling coils.

Interior Miscellaneous Piping Insulation Application Schedule (40°F to 90°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
All piping	Glass fiber	1"	Yes	None

G. Interior Steam Condensate Piping Insulation Application Schedule (180°F to 250°F): Unless otherwise indicated, insulate the following interior exposed and concealed steam condensate piping according to the Interior Steam Condensate Piping Insulation Application Schedule:

1. Pumped discharge piping.
2. Low pressure condensate return piping.
3. Low pressure process condensate return piping.
4. Medium pressure condensate return piping.
5. High pressure condensate return piping.

Interior Steam Condensate Piping Insulation Application Schedule (180°F to 250°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD- APPLIED JACKET
¾" to 2" (Note 1)	Glass fiber	1"	No	None
¾" to 2"	Glass fiber	1½"	No	None
2½" to 6"	Glass fiber	2"	No	None
8" and up	Glass fiber	3"	No	None

NOTE 1: Applies to runouts to individual terminal units not exceeding 12 feet in length.

H. Interior Low Pressure Steam Piping Insulation Application Schedule (212°F to 250°F): Unless otherwise indicated, insulate the following interior exposed and concealed low pressure steam piping according to the Interior Low Pressure Steam Piping Insulation Application Schedule:

1. Low pressure steam piping.
2. Low pressure process steam piping.

Interior Low Pressure Steam Piping Insulation Application Schedule (212°F to 250°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD- APPLIED JACKET
¾" to 2" (Note 1)	Glass fiber	1"	No	None
¾" to 1¼"	Glass fiber	1½"	No	None
1½" to 4"	Glass fiber	2"	No	None
5" to 10"	Glass fiber	3"	No	None
12" to 36"	Glass fiber	3½"	No	None

NOTE 1: Applies to runouts to individual terminal units not exceeding 12 feet in length.

I. Interior Medium Pressure Steam Piping Insulation Application Schedule (251°F to 305°F): Unless otherwise indicated, insulate all interior exposed and concealed medium pressure steam piping according to the Interior Medium Pressure Steam Piping Insulation Application Schedule:

Interior Medium Pressure Steam Piping Insulation Application Schedule (251°F to 305°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD- APPLIED JACKET
¾" to 2" (Note 1)	Glass fiber	1½"	No	None
¾" to 1¼"	Glass fiber	2"	No	None

2½" to 4"	Glass fiber	2½"	No	None
5" and up	Glass fiber	3½"	No	None

NOTE 1: Applies to runouts to individual terminal units not exceeding 12 feet in length.

J. Interior High Pressure Steam Piping Insulation Application Schedule (306°F to 450°F): Unless otherwise indicated, insulate all interior exposed and concealed high pressure steam piping according to the Interior High Pressure Steam Piping Insulation Application Schedule:

Interior High Pressure Steam Piping Insulation Application Schedule (306°F to 450°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD- APPLIED JACKET
¾" to 2" (Note 1)	Glass fiber	1½"	No	None
¾" to 2"	Glass fiber	2½"	No	None
2½" to 4"	Glass fiber	3"	No	None
5" to 10"	Glass fiber	3½"	No	None
12" and up	Glass fiber	4"	No	None

NOTE 1: Applies to runouts to individual terminal units not exceeding 12 feet in length.

K. Interior Unfired Steam Generator Specialty Piping Insulation Application Schedule (180°F to 250°F): Unless otherwise indicated, insulate the following interior exposed and concealed unfired steam generator specialty piping according to the Interior Unfired Steam Generator Specialty Piping Insulation Application Schedule:

1. Unfired steam generator blowdown piping.

Interior Boiler Specialty Piping Insulation Application Schedule (180°F to 250°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD- APPLIED JACKET
¾" to 2"	Glass fiber	1½"	No	None
2½" to 6"	Glass fiber	2"	No	None
8" and up	Glass fiber	3"	No	None

L. Interior Steam Safety Relief Vent Piping Insulation Application Schedule (212°F): Unless otherwise indicated, insulate all interior exposed and concealed steam safety relief vent piping according to the Interior Steam Safety Relief Vent Piping Insulation Application Schedule:

Interior Steam Safety Relief Vent Piping Insulation Application Schedule (212°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD- APPLIED JACKET
All piping	Glass fiber	1"	No	None

3.11 EXTERIOR INSULATION APPLICATION SCHEDULE

A. This application schedule is for aboveground insulation outside the building. Loose-fill insulation, for belowground piping, is specified in Division 2 piping distribution Sections.

B. Exterior Steam Condensate Piping Insulation Application Schedule (180°F to 250°F): Unless otherwise indicated, insulate the following exterior exposed and concealed steam condensate piping according to the Exterior Steam Condensate Piping Insulation Application Schedule:

1. Pumped discharge piping.
2. High pressure condensate return piping.

Exterior Steam Condensate Piping Insulation Application Schedule (306°F to 450°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS (in inches)	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
½" to 1¼"	Cellular glass	3"	No	A-Note 1
1½" to 4"	Cellular glass	3½"	No	A-Note 1
5" to 10"	Cellular glass	4"	No	A-Note 1
12" to 36"	Cellular glass	4½"	No	A-Note 1

NOTE 1: Provide an aluminum field applied jacket 0.040 inch thick with 1-1/4 by 1/4 inch corrugations.

NOTE 2: Apply insulation over freeze protection heat tracing.

END OF SECTION 15083

SECTION 15110 –VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following general-duty valves for use in HVAC piping system applications:

1. Copper-alloy ball valves.
2. High-pressure butterfly valves.
3. Bronze check valves.
4. Gray-iron swing check valves.
5. Ferrous-alloy wafer check valves.
6. Spring-loaded, lift-disc check valves.
7. Bronze gate valves.
8. Cast-iron gate valves.
9. Bronze globe valves.
10. Cast-iron globe valves.
11. Cast-iron plug valves.
12. Chainwheel actuators.

B. Related Sections include the following:

1. Division 15 Section "Mechanical Identification" for valve tags and charts.
2. Division 15 Section "HVAC Instrumentation and Controls" for control valves and actuators.
3. Division 15 piping Sections for specialty valves applicable to those Sections only.

1.3 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.

1.4 SUBMITTALS

A. General: Comply with pertinent provisions of Division 1 Section - "Submittals and Substitutions" and Division 15 Section - "Basic Mechanical Requirements".

B. Product Data: For each type of valve indicated, include a valve schedule indicating the following:

1. Piping system and valve size range applicable to valve each valve type.
2. Valve design and arrangement.
3. Body, seating, and trim materials.
4. End connections.
5. Pressure and temperature classification.
6. Dimensions and required clearances.
7. Shipping, installed, and operating weights.
8. Specialties and accessories.

C. Maintenance Data: List of parts for each type of valve and maintenance guide to include in the maintenance manuals specified in Division 1 and Division 15 – "Basic Mechanical Methods and Materials". Include detailed manufacturer's instructions on adjusting, servicing, disassembling, and repairing.

1.5 QUALITY ASSURANCE

A. Single-Source Responsibility: All valves of similar type shall be of a single manufacturer.

B. ASME Compliance (up to 125 psig SWP): ASME B31.9 for building services piping valves.

C. ASME Compliance (125 psig SWP to 300 psig SWP): ASME B31.1 for power piping valves.

D. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

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. 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 VALVES, GENERAL

A. Refer to Part 3 "Valve Applications" Article for applications of valves.

B. Bronze Valves: NPS 2 (DN 50) and smaller with threaded ends, unless otherwise indicated.

C. Ferrous Valves: NPS 2-1/2 (DN 65) 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 (DN 200) and larger.
3. Handwheel: For valves other than quarter-turn types.
4. Lever Handle: For quarter-turn valves NPS 6 (DN 150) 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. Extended Valve Stems: On insulated valves.

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.

J. Threaded: With threads according to ASME B1.20.1.

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

2.2 COPPER-ALLOY BALL VALVES

A. Manufacturers: Subject to compliance with requirements, provide copper-alloy ball valves by one of the following:

1. Ball Valves Type (BLV-A):

a. Jomar. – T-100-SS

B. Ball Valves Type (BLV-A): MSS SP-110, Class 150, 600-psi (4140-kPa) CWP, ASTM B 584 bronze body and bonnet, 2-piece construction; chrome-plated brass or red bronze ball, full port for 1-inch valves and smaller and standard port for 1-¼ inch valves and larger; blowout proof; bronze or brass stem; Teflon seats and seals; threaded end connections:

1. Operator: Lever operators with vinyl grip, lockable.

2. Stem Extension: For valves installed in insulated piping.

2.3 HIGH PERFORMANCE BUTTERFLY VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Butterfly Valves Type (BTFY-A):

a. Grinnell Corp. Figure LC-8281-3
b. General Signal; DeZurik Unit. Figure 632LD-RS66-1
c. Stockham Valves & Fittings, Inc. Figure LG-752-BS-3E

2. Butterfly Valves Type (BTFY-B):

a. Grinnell Corp. Figure LC-8282-3
b. General Signal; DeZurik Unit. Figure 632LD-RS66-1
c. Stockham Valves & Fittings, Inc. Figure LG-722-BS-3E

3. Butterfly Valves Type (BTFY-C):

a. Grinnell Corp. Figure M15L-32M5-4

B. Butterfly Valves Type (BTFY-A): MSS SP-67, 200-psi (1380-kPa) CWP, 150-psi (1035- kPa) maximum pressure differential, ASTM A 126 cast-iron body, extended neck, 416 or 410 stainless-steel stem with upper and lower bronze bushings, resilient EPDM seat, lug style with bi-directional shut-off capability and dead end service to 150-psig:

1. Disc Type: Aluminum-Bronze.
2. Operator: Standard lever handle with 10 position (minimum) memory stop.

C. Butterfly Valves Type (BTFY-B): MSS SP-67, 200-psi (1380-kPa) CWP, 150-psi (1035- kPa) maximum pressure differential, ASTM A 126 cast-iron body, extended neck, 416 or 410

stainless-steel stem with upper and lower TFE bushings, resilient EPDM seat, lug style with bi-directional shut-off capability and dead end service to 150-psig:

1. Disc Type: Aluminum-Bronze.
2. Operator: Gear operator with handwheel and position indicator. Provide chain wheel operators for valves installed over 96 inches above the floor.

D. Butterfly Valves Type (BTFY-C): MSS SP-68, ANSI Class 150, BS 1400 AB2 aluminum-bronze body and disc, Inconel 625 metal seat, K-Monel shaft and disc pin, PTFE composite shaft bearing on top and bottom, graphite body gasket and gland packing, lug style with bi-directional shut-off capability and dead end service to 150-psig WSP:

1. Operator: Gear operator with handwheel and position indicator. Provide chain wheel operators for valves installed over 96 inches above the floor.

2.4 CHECK VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Swing Check Valves Type (SWG-A):
   a. Jomar International – No. T-511

2. Swing Check Valves Type (SWG-B):

   a. Grinnell Corp. – Figure 6300A
   b. Crane Company; Valves and Fitting Division – Figure 373
   c. Hammond Valve Corporation – Figure IR1124
   d. Lunkenheimer/Cincinnati Valve Co. – Figure 1790
   e. Milwaukee Valve Company, Inc. – Figure 2974
   f. Stockham Valves & Fittings, Inc. – Figure G-931
   g. Jenkins – Figure 624
   h. Powell – Figure 559
   i. Fairbanks – Figure 0702

3. Swing Check Valves Type (SWG-C):

   a. Grinnell Corp. – Figure 3370
   b. Crane Company; Valves and Fitting Division – Figure 76E
   c. Hammond Valve Corporation – Figure IB952
   d. Lunkenheimer/Cincinnati Valve Co. – Figure 624
   e. Milwaukee Valve Company, Inc. – Figure 517
   f. Stockham Valves & Fittings, Inc. – Figure B-375
   g. Jenkins – Figure 962A
   h. Powell – Figure 563-Y
   i. Fairbanks – Figure 0606

4. Wafer Check Valves Type (SLT-A):

   a. Grinnell Corp. – Figure 3600
   b. Milwaukee Valve Company, Inc. – Figure 14
   c. Hammond Valve Corporation – Figure IB958

5. Wafer Check Valves Type (SLT-B):

   a. Milwaukee Valve Company, Inc. – Figure 18

B. Swing Check Valves Type (SWG-A): MSS SP-80; Class 125, 150-psi (1380-kPa) WSP; horizontal swing, Y-pattern, ASTM B 62 cast-bronze body and cap, rotating bronze disc with teflon seat, threaded end connections.

C. Swing Check Valves Type (SWG-B): MSS SP-71, Class 125, 200-psi (1380-kPa) CWP, ASTM A 126 Class B cast-iron body and bolted cap, horizontal-swing bronze renewable disc, flanged end connections.

D. Swing Check Valves Type (SWG-C): MSS SP-80; Class 300, 600-psi CWP; horizontal swing, Y-pattern, ASTM B 61 bronze body and cap, regrinding type, renewable bronze disc with bronze seat, threaded end connections:

E. Silent (Wafer) Check Valves Type (SLT-A): Class 125, 200-psi (1380-kPa) CWP, ASTM A 126 cast-iron body, bronze disc, stainless-steel set screws and springs, Bronze bushings, installed between flanges.

F. Silent (Wafer) Check Valves Type (SLT-B): Class 125, 200-psi (1380-kPa) CWP, ASTM A 48 cast-iron globe style body, renewable bronze disc and seat, stainless-steel pins and springs, bronze bushings, installed between flanges.

2.5 BRONZE GATE VALVES

A. Manufacturers: Subject to compliance with requirements, provide bronze gate valves by one of the following:

1. Gate Valves Type (GTV-A):

   a. Grinnell Corp. - Figure #3000
   b. Crane Co.; Crane Valve Group; Crane Valves - Figure 438
   c. Hammond Valve Corporation - Figure IB645
   d. Cincinnati Valve Co. - Figure 2129
   e. Milwaukee Valve Company, Inc. - Figure 105
   f. Crane Co., Crane Valve Group; Stockham Div. – Figure B-110
   g. Crane Co., Crane Valve Group; Jenkins Valves – Figure 370
   h. Powell – Figure 507
   i. Fairbanks – Figure 0250

2. Gate Valves Type (GTV-B):

a. Grinnell Corp. - Figure #3090
b. Crane Co.; Crane Valve Group; Crane Valves - Figure 435UB
c. Hammond Valve Corporation - Figure IB631
d. Cincinnati Valve Co. - Figure 3150
e. Milwaukee Valve – Figure 1151
f. Crane Co., Crane Valve Group; Jenkins Valves – Figure 64U
g. Powell – Figure 2714
h. Fairbanks – Figure U-0228

B. Gate Valves Type (GTV-A): MSS SP-80; Class 125, 200-psi (1380-kPa) cold working pressure (CWP); ASTM B 62 cast-bronze body and union bonnet, solid-bronze wedge, copper-silicon alloy rising stem, Teflon-impregnated packing with bronze packing nut, threaded end connections; and with aluminum or malleable-iron handwheel.

C. Gate Valves Type (GTV-B): MSS SP-80; Class 150, 300-psi (2070-kPa) CWP; ASTM B 62 cast-bronze body and union bonnet, solid-bronze wedge, copper-silicon alloy rising stem, Teflon-impregnated packing with bronze packing nut, threaded end connections; and with aluminum or malleable-iron handwheel.

2.6 CAST-IRON GATE VALVES

A. Manufacturers: Subject to compliance with requirements, provide cast-iron gate valves by one of the following:

1. Gate Valves Type (GTV-C):

a. Grinnell Corp. - Figure #6020A
b. Crane Co.; Crane Valve Group; Crane Valves - Figure 465½
c. Hammond Valve Corporation - Figure IR1140
d. Milwaukee Valve Company, Inc. - Figure F2885
e. Lunkenheimer/Cincinnati Valve Co. - Figure 1430
f. Crane Co., Crane Valve Group; Stockham Div. – Figure G-623
g. Crane Co., Crane Valve Group; Jenkins Valves – Figure 651A
h. Powell – Figure 1793
i. Fairbanks – Figure 0405

2. Gate Valves Type (GTV-D):

a. Grinnell Corp. - Figure #6100A
b. Crane Co.; Crane Valve Group; Crane Valves - Figure 7½E
c. Hammond Valve Corporation - Figure IR330
d. Milwaukee Valve Company, Inc. - Figure F2894
e. Cincinnati Valve Co. - Figure 1436
f. Crane Co., Crane Valve Group; Stockham Div. – Figure F-667
g. Crane Co., Crane Valve Group; Jenkins Valves – Figure 204

h. Powell – Figure 1797
i. Fairbanks – Figure 0312

B. Gate Valves Type (GTV-C): MSS SP-70, Class 125, 200-psi (1380-kPa) CWP, ASTM A 126, Class B cast-iron body and bonnet, solid cast-iron wedge, brass-alloy stem, outside screw and yoke, bolted bonnet, Teflon-impregnated packing with 2-piece packing gland assembly, flanged end connections; and with cast-iron handwheel.

C. Gate Valves Type (GTV-D): MSS SP-70, Class 250, 500-psi CWP, ASTM A 126 cast-iron body and bonnet, solid cast-iron ASTM A 126 wedge, cast bronze ASTM B 584 seats, brass-alloy stem, outside screw and yoke, Teflon-impregnated packing with 2-piece packing gland assembly, bolted bonnet, flanged end connections; and with ASTM A 126 Class B cast-iron handwheel.

2.7 BRONZE GLOBE VALVES

A. Manufacturers: Subject to compliance with requirements, provide bronze globe valves by one of the following:

1. Globe Valves Type (GLB-A):

a. Grinnell Corp. – Figure 3240
b. Crane Company; Valves and Fitting Division. – Figure 7-TF
c. Hammond Valve Corporation. – Figure IB413T
d. Cincinnati Valve Co. – Figure 123
e. Milwaukee Valve Company, Inc. – Figure 590
f. NIBCO Inc. – Figure T-235Y
g. Crane Co., Crane Valve Group; Stockham Div. – Figure B-22-T
h. Crane Co., Crane Valve Group; Jenkins Valves – Figure 106-A-2
i. Powell – Figure 150
j. Fairbanks – Figure 4195-3

2. Globe Valves Type (GLB-B):

a. Grinnell Corp. – Figure 3255
b. Crane Co, Crane Valve Group, Crane Valves – Figure 362E
c. Hammond Valve Corporation. – Figure IB412
d. Cincinnati Valve Co. – Figure 409
e. NIBCO Inc. – Figure T-275-B
f. Crane Co., Crane Valve Group; Stockham Div. – Figure B-66
g. Crane Co., Crane Valve Group; Jenkins Valves – Figure 1103
h. Powell – Figure 120
i. Fairbanks – Figure 033

B. Globe Valves Type (GLB-A): MSS SP-80; Class 150, 300-psi (2070-kPa) 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 end connections; and with aluminum or malleable-iron handwheel.

C. Globe Valves Type (GLB-B): MSS SP-80; Class 300, 600-psi CWP; ASTM B 61 bronze body and screwed bonnet, bronze disc and seat, silicon bronze-alloy stem, renewable seat rings, threaded end connections; and with aluminum or malleable-iron handwheel.

2.8 CAST-IRON GLOBE VALVES

A. Manufacturers: Subject to compliance with requirements, provide cast-iron globe valves by one of the following:

1. Globe Valves Type (GLB-C):

   a. Grinnell Corp. – Figure 6200A
   b. Crane Co., Crane Valve Group; Crane Valves – Figure 351
   c. Hammond Valve Corporation. – Figure IR116
   d. Cincinnati Valve Co. – Figure 1123
   e. Milwaukee Valve Company, Inc. – Figure F2981
   f. NIBCO Inc. – Figure F-718-B
   g. Crane Co., Crane Valve Group; Stockham Div. – Figure G-512
   h. Crane Co., Crane Valve Group; Jenkins Valves – Figure 613
   i. Powell – Figure 241
   j. Fairbanks – Figure 0131

2. Globe Valves Type (GLB-D):

   a. Grinnell Corp. – Figure 6250A
   b. Crane Co., Crane Valve Group; Crane Valves – Figure 21E
   c. Hammond Valve Corporation. – Figure IR313
   d. Cincinnati Valve Co. – Figure 884
   e. Milwaukee Valve Company, Inc. – Figure F2983
   f. NIBCO Inc. – Figure F-768-B
   g. Crane Co., Crane Valve Group; Stockham Div. – Figure G-532
   h. Crane Co., Crane Valve Group; Jenkins Valves – Figure 923
   i. Powell – Figure 256
   j. Fairbanks – Figure 0110

B. Globe Valves Type (GLB-C): MSS SP-85, Class 125, 200-psi (1380-kPa) CWP, ASTM A 126 Class B 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 ASTM A 126 Class B cast-iron handwheel.

C. Globe Valves Type (GLB-D): MSS SP-45, Class 250, 500-psi CWP, ASTM A 126 Class B cast-iron body and bolted bonnet with bronze fittings, renewable bronze seat and disc, brass-alloy stem, outside screw and yoke, rising stem, Teflon-impregnated packing with cast-iron follower, flanged end connections; and with ASTM A 126 Class B cast-iron handwheel.

2.9 CAST-IRON PLUG VALVES

A. Manufacturers: Subject to compliance with requirements, provide cast-iron plug valves by one of the following:

1. Plug Valves Type (PLG-A):

a. Grinnell Corp.
b. DeZurik.
c. NIBCO Inc.

B. Plug Valves Type (PLG-A): MSS SP-78, 175-psi (1200-kPa) CWP, ASTM A 126 cast-iron body and bonnet, cast-iron plug, Teflon packing, flanged end connections:

1. Operator: Gear operator with handwheel and position indicator.

2.10 CHAINWHEEL ACTUATORS

A. Available Manufacturers:

B. Manufacturers:

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries, Inc.

C. 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.

1. 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 INSTALLATION

A. Piping installation requirements are specified in other Division 15 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 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) 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.
2. Dual-Plate Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

3.3 JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

B. 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.

3.4 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.

3.5 VALVE APPLICATIONS

A. Refer to piping Sections for specific valve applications.

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. Non-Potable Water Systems (Cold Water Make-up): Use valve types according to the following schedule:

NON-POTABLE WATER SERVICE
Maximum Temperature - 150°F
Maximum Pressure (1/2"-12") – 150 psig

Type of Valve	Size	Specification Valve Type	Application Notes
Gate Valve	--	--	Not Used
Ball Valve	½"-2"	BLV-A	Throttling and Isolation
Globe Valve	½"-2"	GLB-A	Bypass
Swing Check Valve	½"-2"	SWG-A	Prevent Flow Reversal in Piping

D. Domestic Water Systems (Cold, Hot,and Hot Water Recirculation): Use valve types according to the following schedule:

DOMESTIC WATER SERVICE
Maximum Temperature - 250°F
Maximum Pressure (1/2"-12") – 175 psig
Maximum Pressure (14"-24") – 125 psig

Type of Valve	Size	Specification Valve Type	Application Notes
Gate Valve	--	--	Not Used
Ball Valve	½"-2"	BLV-A	Throttling and Isolation
Butterfly Valve	2½"-6"	BTFY-A	Isolation
Butterfly Valve	8"-12"	BTFY-B	Isolation

E. Heating Hot Water Systems: Use valve types according to the following schedule:

HEATING HOT WATER SERVICE
Maximum Temperature - 250°F
Maximum Pressure (1/2"-12") – 175 psig
Maximum Pressure (14"-24") – 125 psig

Type of Valve	Size	Specification Valve Type	Application Notes
Gate Valve	--	--	Not Used
Ball Valve	½"-2"	BLV-A	Throttling and Isolation

Type of Valve	Size	Specification Valve Type	Application Notes
Butterfly Valve	2½"-6"	BTFY-A	Isolation
Butterfly Valve	8"-12"	BTFY-B	Isolation
Globe Valve	½"-2"	GLB-A	ATC Modulation and Bypass
Globe Valve	2½"-10"	GLB-C	ATC Modulation and Bypass
Plug Valve	2½"-10"	PLG-A	Balancing @ Pump Disch. (Note 1)
Swing Check Valve	½"-2"	SWG-A	Prevent Flow Reversal in Piping
Swing Check Valve	2½"-12"	SWG-B	Prevent Flow Reversal in Piping
Silent (Wafer) Check	½"-2"	SLT-A	Prevent Flow Reversal @ Pump Disch.
Silent (Wafer) Check	2½"-12"	SLT-B	Prevent Flow Reversal @ Pump Disch.

NOTE 1: Balancing valves ½"-2" and balancing valves required at terminal equipment shall be calibrated balancing valves as specified in Division 15 Section- "Hydronic Piping".

F. Chilled Water Systems: Use valve types according to the following schedule:

CHILLED WATER SERVICE
Maximum Temperature - 150°F
Maximum Pressure (1/2"-12") – 150 psig
Maximum Pressure (14"-24") – 125 psig

Type of Valve	Size	Specification Valve Type	Application Notes
Gate Valve	--	--	Not Used
Ball Valve	½"-2"	BLV-A	Throttling and Isolation
Butterfly Valve	2½"-6"	BTFY-A	Isolation
Butterfly Valve	8"-12"	BTFY-B	Isolation
Globe Valve	½"-2"	GLB-A	ATC Modulation and Bypass
Globe Valve	2½"-10"	GLB-C	ATC Modulation and Bypass
Plug Valve	2½"-10"	PLG-A	Balancing @ Pump Disch. (Note 1)
Swing Check Valve	½"-2"	SWG-A	Prevent Flow Reversal in Piping
Swing Check Valve	2½"-12"	SWG-B	Prevent Flow Reversal in Piping
Silent (Wafer) Check	½"-2"	SLT-A	Prevent Flow Reversal @ Pump Disch.
Silent (Wafer) Check	2½"-12"	SLT-B	Prevent Flow Reversal @ Pump Disch.

NOTE 1: Balancing valves ½"-2" and balancing valves required at terminal equipment shall be calibrated balancing valves as specified in Division 15 Section- "Hydronic Piping".

G. Low Pressure Saturated Steam Systems: Use valve types according to the following schedule:

LOW PRESSURE SATURATED STEAM SERVICE

Maximum Temperature - 250°F
Operating Pressure – 0-15 psig

Type of Valve	Size	Specification Valve Type	Application Notes
Gate Valve	½"-2"	GTV-A	Isolation
Gate Valve	2½"-16"	GTV-C	Isolation
Ball Valve	--	--	Not Used
Butterfly Valve	--	--	Not Used
Globe Valve	½"-2"	GLB-A	Bypass (Manual Modulation)
Globe Valve	2-½"-10"	GLB-C	Bypass (Manual Modulation)
Plug Valve	--	--	Not Used

H. Medium Pressure Saturated Steam Systems: Use valve types according to the following schedule:

MEDIUM AND HIGH PRESSURE SATURATED STEAM SERVICE
Maximum Temperature - 366°F
Operating Pressure – 16-150 psig

Type of Valve	Size	Specification Valve Type	Application Notes
Gate Valve	½"-2"	GTV-B	Isolation
Gate Valve	2½"-12"	GTV-D	Isolation
Ball Valve	--	--	Not Used
Butterfly Valve	--	--	Not Used
Globe Valve	½"-2"	GLB-B	Bypass (Manual Modulation)
Globe Valve	2-½"-10"	GLB-D	Bypass (Manual Modulation)
Plug Valve	--	--	Not Used

I. Low Pressure (Steam) Condensate Return Systems: Use valve types according to the following schedule:

LOW PRESSURE CONDENSATE SERVICE
Maximum Temperature - 250°F
Operating Pressure – 0-15 psig

Type of Valve	Size	Specification Valve Type	Application Notes
Gate Valve	--	--	Not Used
Ball Valve	½"-2"	BLV-A	Throttling and Isolation
Butterfly Valve	2-½"-6"	BTFY-C	Isolation
Globe Valve	½"-2"	GLB-A	Bypass
Globe Valve	2-½"-10"	GLB-C	Bypass

Type of Valve	Size	Specification Valve Type	Application Notes
Plug Valve	2-½"-10"	PLG-A	Balancing @ Pump Disch.
Swing Check Valve	½"-2"	SWG-A	Prevent Flow Reversal in Piping
Swing Check Valve	2-½"-12"	SWG-B	Prevent Flow Reversal in Piping
Silent (Wafer) Check	½"-2"	SLT-A	Prevent Flow Reversal @ Pump Disch.
Silent (Wafer) Check	2-½"-12"	SLT-B	Prevent Flow Reversal @ Pump Disch.

J. Medium Pressure (Steam) Condensate Return Systems: Use valve types according to the following schedule:

MEDIUM AND HIGH PRESSURE CONDENSATE SERVICE
Maximum Temperature - 366°F
Operating Pressure – 0-150 psig

Type of Valve	Size	Specification Valve Type	Application Notes
Gate Valve	--	--	Not Used
Ball Valve	½"-2"	BLV-A	Throttling and Isolation
Globe Valve	½"-2"	GLB-B	Bypass
Swing Check Valve	½"-2"	SWG-C	Prevent Flow Reversal in Piping

K. Pumped Condensate Systems: Use valve types according to the following schedule:

PUMPED CONDENSATE SERVICE
Maximum Temperature - 250°F
Operating Pressure – 0-15 psig

Type of Valve	Size	Specification Valve Type	Application Notes
Gate Valve	--	--	Not Used
Ball Valve	½"-2"	BLV-A	Throttling and Isolation
Butterfly Valve	2-½"-6"	BTFY-C	Isolation
Globe Valve	½"-2"	GLB-A	ATC Modulation and Bypass
Globe Valve	2-½"-10"	GLB-C	ATC Modulation and Bypass
Plug Valve	2-½"-10"	PLG-A	Balancing @ Cond Pump Disch.
Swing Check Valve	½"-2"	SWG-A	Prevent Flow Reversal in Piping
Swing Check Valve	2-½"-12"	SWG-B	Prevent Flow Reversal in Piping
Silent (Wafer) Check	½"-2"	SLT-A	Prevent Flow Reversal @ Pump Disch.
Silent (Wafer) Check	2-½"-12"	SLT-B	Prevent Flow Reversal @ Pump Disch.

END OF SECTION 15110

SECTION 15121 - PIPE EXPANSION FITTINGS AND LOOPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following pipe expansion joints and expansion compensation devices for mechanical piping systems:

1. Metal-bellows expansion joints.
2. Expansion compensators.
3. Externally pressurized, guided expansion joints
4. In-Line Seismic expansion joints.
5. Low pressure duct expansion joints.
6. Rubber expansion joints.
7. Flexible ball joints.
8. Pipe bends and loops.
9. 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.

G. PTFE: Polytetrafluoroethylene plastic.

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 pipe expansion joint and alignment guide indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer.

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

D. Welding certificates.

E. Operation and Maintenance Data: For pipe expansion joints to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding: 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 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 EXTERNALLY PRESSURIZED, GUIDED EXPANSION JOINTS

A. Manufacturers:

1. Hyspan Precision Products, Inc. – Series 3500.

B. Metal-Bellows Expansion Joints: ASTM F 1120, circular-corrugated-bellows type, totally enclosed, externally pressurized, guided expansion joints. Provide drain port.

1. Metal-Bellows Expansion Joints for Steel Piping: Multiple-ply stainless-steel bellows, steel pipe end connections, and carbon-steel shroud.
2. Minimum Pressure Rating: 150 psig (1035 kPa), unless otherwise indicated.
3. Configuration: Laminated-bellows type, unless otherwise indicated.
4. End Connections: Flanged.

2.3 IN-LINE SEISMIC EXPANSION JOINT

A. Manufacturers:

1. Hyspan Precision Products, Inc. – Series 3500IS.

B. Double ball joint style with multiply 304 stainless steel externally pressurized metal bellows, expansion joint for steel piping:

1. Ratings: 150 PSI, 400 degrees F.
2. Horizontal installation.
3. Pipe shall be A53 Gr. B, schedule standard as minimum.
4. Ball joint at each end.
5. 3-ply bellows, externally pressurized.
6. Minimum design fatigue life shall be 100 cycles.
7. Internal vented guiding.
8. Integral ¾"-3000# A105 drain with plug.
9. Anchor per Manufacturer's guidelines. Refer to plans.
10. End Connections for Steel Pipe, flanged and welded as scheduled.

2.4 LOW PRESSURE DUCT EXPANSION JOINTS

A. Manufacturers:

1. Hyspan Precision Products, Inc. – Series 2500.

B. Low pressure expansion joint for discharge duct application: Circular-corrugated-bellows type, expansion joint.
Metal-Bellows Expansion Joints for Steel Piping:

1. Ratings: 15 PSI, 300 degrees F.
2. Horizontal installation.

3. Pipe-carbon steel.
4. Minimum design fatigue life shall be 100 cycles.
5. End Connections for Steel Pipe, flanged as scheduled.
6. Installation required gasket. See duct accessory specification. Also refer to plans and details.

2.5 BELLOWS PUMP CONNECTORS

A. Manufacturers:

1. Hyspan Precision Products, Inc. – Series 5500.

B. Expansion Compensators: Multiple-ply corrugated stainless-steel bellows in a housing with external restraints.

1. Minimum Pressure Rating: 150 psig (1035 kPa), unless otherwise indicated.
2. Configuration for Steel Piping: Two-ply stainless-steel bellows and carbon-steel shroud.
3. End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
4. End Connections for Steel Pipe NPS 2-1/2 and up(DN 65 to DN 100): Flanged.

2.6 RUBBER EXPANSION JOINTS

A. Manufacturers:

1. Mason Industries, Inc.; Mercer Rubber Co.
2. Metraflex, Inc.
3. Vibration Mountings & Controls, Inc.

B. Description: 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. Spherical Type: Multiple spheres.

   a. Minimum Pressure and Temperature Ratings forNPS 1-1/2 to NPS 4 (DN 40 to DN 100): 150 psig (1035 kPa) at 220 deg F (104 deg C).
   b. Minimum Pressure and Temperature Ratings for NPS 5 and NPS 6 (DN 125 and DN 150): 140 psig (966 kPa) at 200 deg F (93 deg C).
   c. Minimum Pressure and Temperature Ratings forNPS 8 to NPS 12 (DN 200 to DN 300): 140 psig (966 kPa) at 180 deg F (82 deg C).

2. Material: EPDM.
3. End Connections: Full-faced, integral, steel flanges with steel retaining rings.

2.7 FLEXIBLE BALL JOINTS

A. Manufacturers:

1. Hyspan Precision Products, Inc. – Series 6500 Type N Style I.

B. 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 (1725 kPa at 204 deg C) 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 (DN 150) and Smaller: 30-degree minimum.
2. Angular Deflection for NPS 8 (DN 200) and Larger: 15-degree minimum.
3. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
4. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.

2.8 PREFABRICATED PIPING EXPANSION LOOPS

A. Manufacturers:
1. The Metraflex Company

B. Description: Model ML; Two flexible sections of hose and braid, two 90 degree elbows, and a 180 degree return with connections suited to application.
1. Minimum Pressure and Temperature Ratings: 150 psig (1035 kPa) at 220 deg F (104 deg C).

2.9 ALIGNMENT GUIDES

A. Manufacturers:

1. Hyspan Precision Products, Inc.
2. Metraflex, Inc.
3. Advanced Thermal Systems, Inc.

B. 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.

2.10 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 (20.7 MPa) minimum. Refer to Division 3 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 (34.5-MPa), 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 manufactured, metallic expansion joints according to Manufacturer's guidelines.

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

D. 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.

C. Install prefabricated expansion loops at all locations where piping crosses a seismic joint.

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 joints and bends 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 15121

SECTION 15122 - METERS AND GAGES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following meters and gages for mechanical systems:

1. Thermometers.
2. Gages.
3. Test plugs.

B. Related Sections include the following:

1. Division 15 Section "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.

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.

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.

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 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

A. Manufacturers:

1. Trerice, H. O. Co.
2. Weiss Instruments, Inc.
3. Palmer - Wahl Instruments Inc.
4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Case: Die-cast aluminum or brass 9 inches (229 mm) long.

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

D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.

E. Window: Glass or plastic.

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. Manufacturers:

1. Trerice, H. O. Co.
2. Weiss Instruments, Inc.
3. Palmer - Wahl Instruments Inc.

B. Case: Metal or plastic, 7 inches (178 mm) long.

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

D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.

E. Window: Glass or plastic.

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

G. Stem: Metal, for installation in mounting bracket and of length to suit installation.

H. Mounting Bracket: Flanged fitting for attachment to duct and made to hold thermometer stem.

I. 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 THERMOWELLS

A. Manufacturers:

1. Trerice, H. O. Co.
2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
3. Ernst Gage Co.
4. Marsh Bellofram.
5. Palmer - Wahl Instruments Inc.
6. Weiss Instruments, Inc.
7. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

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

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

2.5 PRESSURE GAGES

A. Manufacturers:

1. Ernst Gage Co.
2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
3. Eugene Ernst Products Co.
4. Marsh Bellofram.
5. Palmer - Wahl Instruments Inc.
6. Trerice, H. O. Co.
7. Weiss Instruments, Inc.
8. 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: Liquid-filled type, metal or plastic, 4-1/2-inch (114-mm) diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4 (DN 8), 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 or other dark-color metal.
7. Window: Glass or plastic.
8. Ring: Metal or plastic.
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 (100 kPa of vacuum to 103 kPa of pressure).
11. Range for Fluids under Pressure: Two times operating pressure.

C. Pressure-Gage Fittings:

1. Valves: NPS 1/4 (DN 8) brass or stainless-steel needle type.
2. Syphons: NPS 1/4 (DN 8) coil of brass tubing with threaded ends.
3. Snubbers: ASME B40.5, NPS 1/4 (DN 8) brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.6 TEST PLUGS

A. Manufacturers:

1. Trerice, H. O. Co.
2. Flow Design, Inc.
3. National Meter, Inc.
4. 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 (3450 kPa at 93 deg C).

D. 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 (minus 7 to plus 93 deg C) shall be CR.
2. Insert material for air or water service at minus 30 to plus 275 deg F (minus 35 to plus 136 deg C) shall be EPDM.

E. Test Kit: Furnish one test kit(s) containing one pressure gage and adaptor, one thermometer(s), 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- (51- to 76-mm-) diameter dial and probe. Dial range shall be 0 to 200 psig (0 to 1380 kPa).
2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F (minus 4 to plus 52 deg C).
3. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F (minus 18 to plus 104 deg C).
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:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
3. Inlet and outlet of each hydronic heat exchanger.
4. Outside-air, return-air, and mixed-air ducts.
5. At all other locations indicated on the Drawings.

B. Provide the following temperature ranges for thermometers:

1. Domestic Hot Water: 30 to 180 deg F, with 2-degree scale divisions.
2. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions.
3. Heating Hot Water: 30 to 240 deg F, with 2-degree scale divisions.
4. Chilled Water: 0 to 100 deg F, with 2-degree scale divisions.
5. Steam and Condensate: 30 to 300 deg F, with 5-degree scale divisions.
6. Air Ducts: Minus 40 to plus 110 deg F, with 2-degree scale divisions.

3.2 GAGE APPLICATIONS

A. Install dry-case-type pressure gages for discharge of each pressure-reducing valve.

B. Install liquid-filled-case-type pressure gages at chilled- and condenser-water inlets and outlets of chillers.

C. Install liquid-filled-case-type pressure gages at suction and discharge of each pump.

3.3 INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions.

B. Install thermowells with socket extending a minimum of 2 inches (51 mm) into fluid and in vertical position in piping tees where thermometers are indicated.

C. Duct Thermometer Support Flanges: Install in wall of duct where duct thermometers are indicated. Attach to duct with screws.

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

E. Install needle-valve and snubber fitting in piping for each pressure gage for fluids (except steam).

F. Install needle-valve and syphon fitting in piping for each pressure gage for steam.

G. Install test plugs in tees in piping.

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

3.4 CONNECTIONS

A. Install gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines, and equipment.

3.5 ADJUSTING

A. Adjust faces of gages to proper angle for best visibility.

END OF SECTION 15122

SECTION 15140 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes domestic water piping from locations indicated to fixtures and equipment inside the building.

B. Related Sections include the following:

1. Division 15 Section "Meters and Gages" for thermometers, pressure gages, and fittings.
2. Division 15 Section "Plumbing Specialties" for water distribution piping specialties.

1.3 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing domestic water piping systems with the following minimum working-pressure ratings, unless otherwise indicated:

1. Dmestic Water Service Piping: 100 psig (690 kPa).
2. Domestic Water Distribution Piping: 80 psig (550 kPa).

1.4 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. Water Samples: Specified in "Cleaning" Article in Part 3.

C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

D. Domestic Hot Water System: Submit water balancing certification report.

E. Acceptable Substitute Manufacturers: All bidders desiring to furnish equipment other than that specified must submit a complete verification specification for the substituted

equipment along with literature, wiring diagrams, piping diagrams, and a list of similar sized installations where proposed equipment is installed. The complete submittal must be presented to the Architect at least (7) full working days prior to the bid opening for approval. Substitutions will not be permitted after the contract has been awarded. Refer to Specification Section 01300, SUBMITTALS AND SUBSTITUTIONS.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances," and NSF 61, "Drinking Water System Components-Health Effects; Sections 1 through 9," for combined fire-protection and domestic water service piping to building.

C. Comply with NSF 61, "Drinking Water System Components-Health Effects; Sections 1 through 9," for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

B. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

C. Transition Couplings for Underground Pressure Piping: AWWA C219, metal, sleeve-type coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.2 COPPER TUBING

A. Soft Copper Tube: ASTM B 88, Types K (ASTM B 88M, Types A), 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. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.
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.

B. Hard Copper Tube: ASTM B 88, Types L (ASTM B 88M, Types B), 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. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.
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, Grooved-End Fittings: ASTM B 75 (ASTM B 75M) copper tube or ASTM B 584 bronze castings.

    a. Copper-Tubing, Keyed Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, gasket suitable for hot water, and bolts and nuts.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

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 may be used on aboveground piping, unless otherwise indicated.

C. Grooved joints may be used on aboveground grooved-end piping.

D. Fitting Option: Mechanically formed tee-branch outlets and brazed joints may be used on aboveground copper tubing.

E. Aboveground Domestic Water Piping: Use the following piping materials for each size range:

1. NPS 1-1/2 (DN 40) and Smaller: Hard copper tube, **Type L** copper pressure fittings; and soldered joints.
2. NPS 2 (DN 50): Hard copper tube, **Type L** copper pressure fittings; and soldered joints.
3. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Hard copper tube, **Type L** copper pressure fittings; and soldered joints.
4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Use NPS 2-1/2 to NPS 4 (DN 65 to DN 100) hard copper tube, **Type L** with grooved ends; copper grooved-end fittings; copper-tubing, keyed couplings; and grooved joints.

5. NPS 4 to NPS 6 (DN 100 to DN 150): Hard copper tube, **Type L** with grooved ends; copper grooved-end fittings; copper-tubing, keyed couplings; and grooved joints.
6. NPS 8 (DN 200): Hard copper tube, **Type L** with grooved ends; copper grooved-end fittings; copper-tubing, keyed couplings; and grooved joints.

F. Underground Domestic Water Piping NPS 4 (DN 100) and Smaller: Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.

G. Nonpotable-Water Piping: Use **any of** the following piping materials for each size range:
1. NPS 3-1/2 (DN 90) and Smaller: Hard copper tube, **Type L**; copper pressure fittings; and soldered joints.
2. NPS 4 to NPS 6 (DN 100 to DN 150): Hard copper tube, **Type L** with grooved ends; copper grooved-end fittings; copper-tubing, keyed couplings; and grooved joints.
3. NPS 8 (DN 200): Hard copper tube, **Type L** with grooved ends; copper grooved-end fittings; copper-tubing, keyed couplings; and grooved joints.

3.2 VALVE APPLICATIONS

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use bronze ball valves for piping NPS 2 (DN 50) and smaller. Use cast-iron butterfly or gate valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
2. Throttling Duty: Use bronze ball valves for piping NPS 2 (DN 50) and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
3. Hot-Water-Piping, Balancing Duty: Circuit setter balancing valves with memory stop.
4. Drain Duty: Hose-end drain valves.

B. Cast-iron, grooved-end valves may be used with grooved-end piping.

3.3 PIPING INSTALLATION

A. Refer to Division 2 Section "Water Distribution" for site water distribution and service piping.

B. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation.

C. Extend domestic water service piping to exterior water distribution piping in sizes and locations indicated.

D. 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. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for sleeves and mechanical sleeve seals.

E. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for wall penetration systems.

F. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside building at each domestic water service. Refer to Division 15 Section "Meters and Gages" for pressure gages, and to Division 15 Section "Plumbing Specialties" for drain valves and strainers.

G. Install aboveground domestic water piping level with 0.25 percent slope downward toward drain and plumb.

H. Fill water piping. Check components to determine that they are not air bound and that piping is full of water.

I. Perform the following steps 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. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
5. Remove and clean strainer screens. Close drain valves and replace drain plugs.
6. Remove filter cartridges from housings, and verify that cartridges are as specified for application where used and that cartridges are clean and ready for use.

J. Check plumbing equipment and verify proper settings, adjustments, and operation. Do not operate water heaters before filling with water.

K. Check plumbing specialties and verify proper settings, adjustments, and operation.

1. Water-Pressure Regulators: Set outlet pressure at 80 psig (550 kPa) maximum, unless otherwise indicated.

L. Energize pumps and verify proper operation.

3.4 JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

B. 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.

C. Grooved Joints: Assemble joints with keyed-coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

3.5 VALVE INSTALLATION

A. Install sectional valve close to water main on each branch and riser serving plumbing fixtures or equipment. Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly or gate valves for piping NPS 2-1/2 (DN 65) and larger.

B. Install shutoff valve on each water supply to equipment and on each water supply to plumbing fixtures without supply stops. Use ball valves for piping NPS 2 (DN 50) and smaller. Use butterfly or gate valves for piping NPS 2-1/2 (DN 65) and larger.

C. Install drain valves for equipment, at base of each water riser, at low points in horizontal piping, and where required to drain water piping.

1. Install hose-end drain valves at low points in water mains, risers, and branches.
2. Install stop-and-waste drain valves where indicated.

D. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use circuit setter for piping NPS 2 (DN 50) and smaller. Refer to Division 15 Section "Plumbing Specialties" for balancing valves.

3.6 HANGER AND SUPPORT INSTALLATION

A. Refer to Division 15 Section "Mechanical Vibration Controls and Seismic Restraints" for seismic-restraint devices.

B. Refer to Division 15 Section "Hangers and Supports" for pipe hanger and support devices. Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Individual, Straight, Horizontal Piping Runs: According to the following:

    a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Division 15 Section "Hangers and Supports."

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch (10 mm).

F. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
5. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
6. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
7. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

G. Install supports for vertical copper tubing every 10 feet (3 m).

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 Existing L.L. Bean booster pump water service piping. Use transition fitting to join dissimilar piping materials. Reconnect Richards water service to existing via Charles Street Project.

D. Connect domestic water piping to service piping with shutoff valve, and extend and connect to the following:

1. Booster Systems: Cold-water discharge piping.
2. Water Heaters: Cold-water supply 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. Refer to Division 15 Section "Plumbing Fixtures."
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 (DN 65) and larger.

3.8 FIELD QUALITY CONTROL

A. Inspect domestic water piping as follows:

1. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
2. 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:

    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 for final inspection by 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 test or inspection, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

B. Test domestic water piping 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 domestic water piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Cap and subject piping to static water pressure of 50 psig (345 kPa) 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.
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.

3.9 ADJUSTING

A. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

1. Manually adjust circuit setter balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
2. Adjust calibrated balancing valves to flows indicated.

3.10 CLEANING

A. Clean and disinfect potable and nonpotable domestic water piping as follows:

1. Purge new piping and parts of existing domestic water piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures described in either AWWA C651 or AWWA C652 or as 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 (50 mg/L) 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 (200 mg/L) 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. Prepare and submit reports of purging and disinfecting activities.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

END OF SECTION 15140

SECTION 15150 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes soil and waste, sanitary drainage and vent piping inside the building and to locations indicated.

B. Related Sections include the following:

1. Division 15 Section "Plumbing Specialties" for soil, waste, and vent piping systems specialties.

1.3 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing piping systems with the following minimum working-pressure ratings, unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water (30 kPa).
2. Sanitary Sewer, Force-Main Piping: 150 psig (1035 kPa).

1.4 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. Shop Drawings: For sovent drainage system, include plans, elevations, sections, and details.

C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

D. Acceptable Substitute Manufacturers: All bidders desiring to furnish equipment other than that specified must submit a complete verification specification for the substituted equipment along with literature, wiring diagrams, piping diagrams, and a list of similar sized installations where proposed equipment is installed. The complete submittal must be presented to the Architect at least (7) full working days prior to the bid opening for

approval. Substitutions will not be permitted after the contract has been awarded. Refer to Specification Section 01300, SUBMITTALS AND SUBSTITUTIONS.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

B. Flexible Transition Couplings for Underground Nonpressure Piping: ASTM C 1173 with elastomeric sleeve. Include ends of same sizes as piping to be joined and include corrosion-resistant metal band on each end.

C. Transition Couplings for Underground Pressure Piping: AWWA C219 metal, sleeve-type coupling or other manufactured fitting same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.2 CAST-IRON SOIL PIPING

A. Hub-and-Spigot Pipe and Fittings: ASTM A 74, Extra-Heavy class[es].

1. Gaskets: ASTM C 564, rubber.

B. Hubless Pipe and Fittings: ASTM A 888 or CISPI 301.

1. Couplings: ASTM C 1277 assembly of metal housing, corrosion-resistant fasteners, and ASTM C 564 rubber sleeve with integral, center pipe stop.

a. Heavy-Duty, Type 304, Stainless-Steel Couplings: ASTM A 666, Type 304, stainless-steel shield; stainless-steel bands; and sleeve.

1) NPS 1-1/2 to NPS 4 (DN 40 to DN 100): 3-inch- (76-mm-) wide shield with 4 bands.
2) NPS 5 to NPS 10 (DN 125 to DN 250): 4-inch- (102-mm-) wide shield with 6 bands.

b. Heavy-Duty, FM-Approved Couplings: ASTM A 666, Type 304, stainless-steel housing; stainless-steel bands; and sleeve.

1) NPS 1-1/2 to NPS 4 (DN 40 to DN 100): 3-inch- (76-mm-) wide housing with 2 bands.
2) NPS 5 to NPS 10 (DN 125 to DN 250): 4-inch- (102-mm-) wide housing with 2 bands.

c. Heavy-Duty, Cast-Iron Couplings: ASTM A 48, 2-piece, cast-iron housing; stainless-steel bolts and nuts; and sleeve.

2.3 COPPER TUBING

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 (ASTM B 88M, Types B and C), 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. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
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.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 2 Section "Earthwork" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Transition and special fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.

B. Flanges may be used on aboveground pressure piping, unless otherwise indicated.

C. Aboveground, Soil, Waste, and Vent Piping: Use [any of] the following piping materials for each size range:

1. NPS 1-1/4 and NPS 1-1/2 (DN 32 and DN 40): Use NPS 1-1/2 (DN 40) hubless, cast-iron soil piping and one of the following:

a. Couplings: Heavy-duty, Type [304], stainless steel.
b. Couplings: Heavy-duty, [FM approved] [cast iron].
c. Couplings: Compact, stainless steel.

2. NPS 1-1/4 and NPS 1-1/2 (DN 32 and DN 40): Cast-iron, threaded drainage fittings; and threaded joints.
3. NPS 1-1/4 and NPS 1-1/2 (DN 32 and DN 40): Copper DWV tube, copper drainage fittings, and soldered joints.
4. NPS 2 to NPS 4 (DN 50 to DN 100): Service class, cast-iron soil piping; gaskets; and gasketed joints.
5. NPS 2 to NPS 4 (DN 50 to DN 100): Hubless, cast-iron soil piping and one of the following:

   a. Couplings: Heavy-duty, Type [304], stainless steel.
   b. Couplings: Heavy-duty, [FM approved] [cast iron].
   c. Couplings: Compact, stainless steel.

6. NPS 2 to NPS 4 (DN 50 to DN 100): Copper DWV tube, copper drainage fittings, and soldered joints.

   a. Option for Vent Piping, NPS 2-1/2 and NPS 3-1/2 (DN 65 and DN 90): Hard copper tube, Type M (Type C); copper pressure fittings; and soldered joints.

7. NPS 5 and NPS 6 (DN 125 and DN 150): Service class, cast-iron soil piping; gaskets; and gasketed joints.
8. NPS 5 and NPS 6 (DN 125 and DN 150): Hubless, cast-iron soil piping and one of the following:

   a. Couplings: Heavy-duty, Type [304], stainless steel.
   b. Couplings: Heavy-duty, [FM approved] [cast iron].
   c. Couplings: Compact, stainless steel.

9. NPS 5 and NPS 6 (DN 125 and DN 150): Steel pipe; cast-iron, threaded drainage fittings; and threaded joints.
10. NPS 5 and NPS 6 (DN 125 and DN 150): Use NPS 6 (DN 150) stainless-steel piping, gaskets, and gasketed joints.
11. NPS 5 and NPS 6 (DN 125 and DN 150): Copper DWV tube, copper drainage fittings, and soldered joints.
12. NPS 8 (DN 200): Service class, cast-iron soil piping; gaskets; and gasketed joints.
13. NPS 8 (DN 200): Hubless, cast-iron soil piping and one of the following:

    a. Couplings: Heavy-duty, Type [304], stainless steel.
    b. Couplings: Heavy-duty, [FM approved] [cast iron].
    c. Couplings: Compact, stainless steel.

14. NPS 8 (DN 200): Steel pipe; cast-iron, threaded drainage fittings; and threaded joints.
15. NPS 8 (DN 200): Copper DWV tube, copper drainage fittings, and soldered joints.
16. NPS 10 (DN 250): Service class, cast-iron soil piping; gaskets; and gasketed joints.
17. NPS 10 (DN 250): Hubless, cast-iron soil piping and one of the following:

    a. Couplings: Heavy-duty, Type 304], stainless steel.
    b. Couplings: Heavy-duty, [FM approved] [cast iron].
    c. Couplings: Compact, stainless steel.

18. NPS 12 (DN 300): Service class, cast-iron soil piping; gaskets; and gasketed joints.
19. NPS 12 (DN 300): Hubless, cast-iron soil piping and compact, stainless-steel couplings.
20. NPS 15 (DN 375): Service class, cast-iron soil piping; gaskets; and gasketed joints.
21. NPS 15 (DN 375): Hubless, cast-iron soil piping and compact, stainless-steel couplings.

D. Underground, Soil, Waste, and Vent Piping: Use [any of] the following piping materials for each size range:

1. NPS 1-1/2 (DN 40): Hubless, cast-iron soil piping and one of the following:

    a. Couplings: Heavy-duty, Type [304], stainless steel.
    b. Couplings: Heavy-duty, [FM approved] [cast iron].
    c. Couplings: Compact, stainless steel.

2. NPS 2 to NPS 4 (DN 50 to DN 100): Extra-Heavy class, cast-iron soil piping; gaskets; and gasketed joints.
3. NPS 2 to NPS 4 (DN 50 to DN 100): Hubless, cast-iron soil piping and one of the following:

    a. Couplings: Heavy-duty, Type [304], stainless steel.
    b. Couplings: Heavy-duty, [FM approved] [cast iron].
    c. Couplings: Compact, stainless steel.

4. NPS 5 and NPS 6 (DN 125 and DN 150): Extra-Heavy class, cast-iron soil piping; gaskets; and gasketed joints.
5. NPS 5 and NPS 6 (DN 125 and DN 150): Hubless, cast-iron soil piping and one of the following:

    a. Couplings: Heavy-duty, Type [304], stainless steel.
    b. Couplings: Heavy-duty, [FM approved] [cast iron].
    c. Couplings: Compact, stainless steel.

6. NPS 8 and NPS 10 (DN 200 and DN 250): Extra-Heavy class, cast-iron soil piping; gaskets; and gasketed joints.
7. NPS 8 and NPS 10 (DN 200 and DN 250): Hubless, cast-iron soil piping and one of the following:

a. Couplings: Heavy-duty, Type [304], stainless steel.
b. Couplings: Heavy-duty, [FM approved] [cast iron].
c. Couplings: Compact, stainless steel.

8. NPS 12 (DN 300): Extra-Heavy class, cast-iron soil piping; gaskets; and gasketed joints.
9. NPS 12 (DN 300): Hubless, cast-iron soil piping and compact, stainless-steel couplings.
10.
11. NPS 15 (DN 375): Extra-Heavy class, cast-iron soil piping; gaskets; and gasketed joints.
12. NPS 15 (DN 375): Hubless, cast-iron soil piping and compact, stainless-steel couplings.

3.3 PIPING INSTALLATION

A. Refer to Division 2 Section "Sanitary Sewerage" for Project-site sanitary sewer piping.

B. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation.

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. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for sleeves and mechanical sleeve seals.

F. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for wall penetration systems.

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. Encase underground piping with PE film 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. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

K. Install force mains at elevations indicated.

L. Install engineered soil and waste drainage and vent piping systems in locations indicated and as follows:

1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
2. Cast-Iron, Sovent, Single Stack: Comply with ASSE 1043 and sovent fitting manufacturer's written installation instructions.
3. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

M. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

N. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.4 JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

B. Cast-Iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Gasketed Joints: Make with rubber gasket matching class of pipe and fittings.
2. Hubless Joints: Make with rubber gasket and sleeve or clamp.

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.

D. Grooved Joints: Assemble joint with keyed coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

3.5 VALVE INSTALLATION

A. Refer to Division 15 Section "Valves" for general-duty valves.

B. Shutoff Valves: Install shutoff valve on each sewage pump discharge.

1. Use gate or full-port ball valve for piping NPS 2 (DN 50) and smaller.
2. Use gate valve for piping NPS 2-1/2 (DN 65) and larger.

C. Check Valves: Install swing check valve, downstream from shutoff valve, on each sewage pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to sewage backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
2. Floor Drains: Drain outlet backwater valves, unless drain has integral backwater valve.
3. Install backwater valves in accessible locations.
4. Refer to Division 15 Section "Plumbing Specialties" for backwater valves.

3.6 HANGER AND SUPPORT INSTALLATION

A. Refer to Division 15 Section "Mechanical Vibration Controls and Seismic Restraints" for seismic-restraint devices.

B. Refer to Division 15 Section "Hangers and Supports" for pipe hanger and support devices. Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Individual, Straight, Horizontal Piping Runs: According to the following:

    a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Division 15 Section "Hangers and Supports."

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 (DN 150): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
5. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.
6. NPS 15 (DN 375): 60 inches (1500 mm) with 1-inch (25-mm) rod.
7. Spacing for 10-foot (3-m) lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).

G. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
5. NPS 3 (DN 80): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
7. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
8. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.

I. Install supports for vertical steel piping every 15 feet (4.5 m).

J. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2 (DN 50): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 96 inches (2400 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 (DN 100): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
4. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.

5. NPS 8 to NPS 12 (DN 200 to DN 300): 10 feet (3 m) with 7/8-inch (22-mm) rod.

K. Install supports for vertical stainless-steel piping every 10 feet (3 m).

L. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
3. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
4. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
5. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
6. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

M. Install supports for vertical copper tubing every 10 feet (3 m).

N. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 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. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 15 Section "Plumbing Fixtures."
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 15 Section "Plumbing Specialties."
4. 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 (DN 65) and larger.

D. Connect force-main piping to the following:

1. Sanitary Sewer: To exterior force main or sanitary manhole.
2. Sewage Pumps: To sewage pump discharge.

3.8 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 (30 kPa). 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 (250 Pa). 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.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 50 psig (345 kPa) 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.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.9 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 15150

SECTION 15160 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes storm-drainage piping inside the building and to locations indicated.

B. Related Sections include the following:

1. Division 15 Section "Plumbing Specialties" for storm drainage piping system specialties.
2. Division 15 Section "Sump Pumps."

1.3 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing piping systems with the following minimum working-pressure ratings, unless otherwise indicated:

1. Storm Drainage Piping: 10-foot head of water (30 kPa)].
2. Storm Drainage, Force-Main Piping: 150 psig (1035 kPa).

1.4 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. Shop Drawings: For controlled-flow storm drainage system, include calculations, plans, and details.

C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

D. Acceptable Substitute Manufacturers: All bidders desiring to furnish equipment other than that specified must submit a complete verification specification for the substituted equipment along with literature, wiring diagrams, piping diagrams, and a list of similar sized installations where proposed equipment is installed. The complete submittal must

be presented to the Architect at least (7) full working days prior to the bid opening for approval. Substitutions will not be permitted after the contract has been awarded. Refer to Specification Section 01300, SUBMITTALS AND SUBSTITUTIONS.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

B. Flexible Transition Couplings for Underground Nonpressure Piping: ASTM C 1173 with elastomeric sleeve. Include ends of same sizes as piping to be joined and include corrosion-resistant metal band on each end.

C. Transition Couplings for Underground Pressure Piping: AWWA C219 metal, sleeve-type coupling or other manufactured fitting same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.2 CAST-IRON SOIL PIPING

A. Hub-and-Spigot Pipe and Fittings: ASTM A 74, Extra-Heavy class[es].

1. Gaskets: ASTM C 564, rubber.

B. Hubless Pipe and Fittings: ASTM A 888 or CISPI 301.

1. Couplings: ASTM C 1277 assembly of metal housing, corrosion-resistant fasteners, and ASTM C 564 rubber sleeve with integral center pipe stop.

a. Heavy-Duty, Type 304, Stainless-Steel Couplings: ASTM A 666, Type 304, stainless-steel shield; stainless-steel bands; and sleeve.

1) NPS 1-1/2 to NPS 4 (DN 40 to DN 100): 3-inch- (76-mm-) wide shield with 4 bands.
2) NPS 5 to NPS 10 (DN 125 to DN 250): 4-inch- (102-mm-) wide shield with 6 bands.

b. Heavy-Duty, FM-Approved Couplings: ASTM A 666, Type 304, stainless-steel housing; stainless-steel bands; and sleeve.

1) NPS 1-1/2 to NPS 4 (DN 40 to DN 100): 3-inch- (76-mm-) wide housing with 2 bands.
2) NPS 5 to NPS 10 (DN 125 to DN 250): 4-inch- (102-mm-) wide housing with 2 bands.

c. Heavy-Duty, Cast-Iron Couplings: ASTM A 48, 2-piece, cast-iron housing; stainless-steel bolts and nuts; and sleeve.
d. Heavy-Duty, Type 301, Stainless-Steel Couplings: ASTM A 666, Type 301, stainless-steel shield; stainless-steel bands; and sleeve.

1) NPS 1-1/2 to NPS 4 (DN 40 to DN 100): 3-inch- (76-mm-) wide shield with 4 bands.
2) NPS 5 to NPS 10 (DN 125 to DN 250): 4-inch- (102-mm-) wide shield with 6 bands.

e. Compact, Stainless-Steel Couplings: CISPI 310 with ASTM A 167, Type 301, or ASTM A 666, Type 301, stainless-steel corrugated shield; stainless-steel bands; and sleeve.

1) NPS 1-1/2 to NPS 4 (DN 40 to DN 100): 2-1/8-inch- (54-mm-) wide shield with 2 bands.
2) NPS 5 and NPS 6 (DN 125 and DN 150): 3-inch- (76-mm-) wide shield with 4 bands.
3) NPS 8 and NPS 10 (DN 200 and DN 250): 4-inch- (102-mm-) wide shield with 4 bands.
4) NPS 12 and NPS 15 (DN 300 and DN 375): 5-1/2-inch- (140-mm-) wide shield with 6 bands.

2.3 DUCTILE-IRON PIPING

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end, unless grooved or flanged ends are indicated.

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.

a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2. Ductile-Iron Piping, Grooved-End Fittings: ASTM A 47 (ASTM A 47M), malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.

a. Ductile-Iron-Piping, Keyed Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

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. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.

   a. Gaskets: AWWA C111, rubber.

2. Ductile-Iron, Grooved-End Fittings: ASTM A 47 (ASTM A 47M), malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.

   a. Ductile-Iron-Piping, Keyed Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

3. Ductile-Iron, Flexible Expansion Joints: Compound, ductile-iron fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections. Assemble components for offset and expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
4. Ductile-Iron, Deflection 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.
5. Ductile-Iron, Expansion Joints: Three-piece, ductile-iron assembly consisting of telescoping sleeve 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.

2.4 PERFORATED PVC SUBDRAINAGE PIPING

A. Perforated Pipe and Fittings: Standard Duty perforated PVC pipe shall be IPEX PERF DR35. The pipe shall conform to the requirements of ASTM D-3034 or ASTM F-679. Heavy Duty (SDR 26).

1. Perforations: Two rows of 15 mm holes positioned at 120° radially on the pipe, and spaced to provide a minimum total cross-sectional hole area of 1933 mm2 per meter of length. Pipe shall be supplied with friction-fit bell ends.
2. Geotextile Fabric Sock: Non-woven fabric with an average opening size range of 50 – 150 microns.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 2 Section "Earthwork" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Transition and special fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.

B. Flanges may be used on aboveground pressure piping, unless otherwise indicated.

C. Aboveground Storm Drainage Piping: Use [any of] the following piping materials for each size range:

1. NPS 2 to NPS 4 (DN 50 to DN 100): Service class, cast-iron soil piping; gaskets; and gasketed joints.
2. NPS 2 to NPS 4 (DN 50 to DN 100): Hubless, cast-iron soil piping and one of the following:

    a. Couplings: Heavy-duty, Type 304, stainless steel.
    b. Couplings: Heavy-duty, FM approved cast iron.
    c. Couplings: Compact, stainless steel.
3. NPS 5 and NPS 6 (DN 125 and DN 150): Hubless, cast-iron soil piping and one of the following:

    a. Couplings: Heavy-duty, Type 304, stainless steel.
    b. Couplings: Heavy-duty, FM approved cast iron.
    c. Couplings: Compact, stainless steel.
4. NPS 8 (DN 200): Service class, cast-iron soil piping; gaskets; and gasketed joints.
5. NPS 8 (DN 200): Hubless, cast-iron soil piping and one of the following:

    a. Couplings: Heavy-duty, Type 304, stainless steel.
    b. Couplings: Heavy-duty, FM approved cast iron.
    c. Couplings: Compact, stainless steel.

6. NPS 8 (DN 200): Steel pipe; cast-iron, threaded drainage fittings; and threaded joints.
7. NPS 10 (DN 250): Service class, cast-iron soil piping; gaskets; and gasketed joints.
8. NPS 10 (DN 250): Hubless, cast-iron soil piping and one of the following:

    a. Couplings: Heavy-duty, Type 304, stainless steel.
    b. Couplings: Heavy-duty, FM approved cast iron.
    c. Couplings: Compact, stainless steel.
9. NPS 12 (DN 300): Service class, cast-iron soil piping; gaskets; and gasketed joints.
10. NPS 12 (DN 300): Hubless, cast-iron soil piping and compact, stainless-steel couplings.

11. NPS 15 (DN 375): Service class, cast-iron soil piping; gaskets; and gasketed joints.
12. NPS 15 (DN 375): Hubless, cast-iron soil piping and compact, stainless-steel couplings.

D. Underground Storm Drainage Piping: Use any of the following piping materials for each size range:

1. NPS 3 and NPS 4 (DN 80 and DN 100): Service class, cast-iron soil piping; gaskets; and gasketed joints.
2. NPS 3 and NPS 4 (DN 80 and DN 100): Extra-Heavy class, cast-iron soil piping; gaskets; and gasketed joints.
3. NPS 3 and NPS 4 (DN 80 and DN 100): Hubless, cast-iron soil piping and one of the following:

    a. Couplings: Heavy-duty, Type 304, stainless steel.
    b. Couplings: Heavy-duty, FM approved cast iron.
    c. Couplings: Compact, stainless steel.

4. NPS 5 and NPS 6 (DN 125 and DN 150): Service class, cast-iron soil piping; gaskets; and gasketed joints.
5. NPS 5 and NPS 6 (DN 125 and DN 150): Extra-Heavy class, cast-iron soil piping; gaskets; and gasketed joints.
6. NPS 5 and NPS 6 (DN 125 and DN 150): Hubless, cast-iron soil piping and one of the following:

    a. Couplings: Heavy-duty, Type 304, stainless steel.
    b. Couplings: Heavy-duty, FM approved cast iron.
    c. Couplings: Compact, stainless steel.

7. NPS 8 and NPS 10 (DN 200 and DN 250): Service class, cast-iron soil piping; gaskets; and gasketed joints.
8. NPS 8 and NPS 10 (DN 200 and DN 250): Extra-Heavy class, cast-iron soil piping; gaskets; and gasketed joints.
9. NPS 8 and NPS 10 (DN 200 and DN 250): Hubless, cast-iron soil piping and one of the following:

    a. Couplings: Heavy-duty, Type 304, stainless steel.
    b. Couplings: Heavy-duty, FM approved cast iron.
    c. Couplings: Compact, stainless steel.

10. NPS 12 (DN 300): Service class, cast-iron soil piping; gaskets; and gasketed joints.
11. NPS 12 (DN 300): Extra-Heavy class, cast-iron soil piping; gaskets; and gasketed joints.
12. NPS 12 (DN 300): Hubless, cast-iron soil piping and compact, stainless-steel couplings.
13. NPS 15 (DN 375): Service class, cast-iron soil piping; gaskets; and gasketed joints.

14. NPS 15 (DN 375): Extra-Heavy class, cast-iron soil piping; gaskets; and gasketed joints.
15. NPS 15 (DN 375): Hubless, cast-iron soil piping and compact, stainless-steel couplings.

3.3 PIPING INSTALLATION

A. Refer to Division 2 Section "Storm Drainage" for Project site storm sewer and drainage piping.

B. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation.

C. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers.

D. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.

E. Underground, Ductile-Iron, Piping: Comply with AWWA C600. Install buried piping inside building between wall and floor penetrations and connection to storm sewer piping outside building with restrained joints. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.

1. Encase piping with PE film according to ASTM A 674 or AWWA C105.

F. 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. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for sleeves and mechanical sleeve seals.

G. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for wall penetration systems.

H. 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."

I. Make changes in direction for storm 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.

J. Lay buried building drain 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 instruc-

tions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

K. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:

1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

L. Install force mains at elevations indicated.

M. Install engineered controlled-flow storm drainage piping in locations indicated.

N. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

O. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.4 JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

B. Cast-Iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Gasketed Joints: Make with rubber gasket matching class of pipe and fittings.
2. Hubless Joints: Make with rubber gasket and sleeve or clamp.

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.

D. Grooved Joints: Assemble joint with keyed coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

3.5 VALVE INSTALLATION

A. Refer to Division 15 Section "Valves" for general-duty valves.

B. Shutoff Valves: Install shutoff valve on each sump pump discharge.

1. Use gate or full-port ball valve for piping NPS 2 (DN 50) and smaller.
2. Use gate valve for piping NPS 2-1/2 (DN 65) and larger.

C. Check Valves: Install swing check valve, downstream from shutoff valve, on each sump pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to backlog.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
2. Install backwater valves in accessible locations.
3. Refer to Division 15 Section "Plumbing Specialties" for backwater valves.

3.6 HANGER AND SUPPORT INSTALLATION

A. Refer to Division 15 Section "Mechanical Vibration Controls and Seismic Restraints" for seismic-restraint devices.

B. Refer to Division 15 Section "Hangers and Supports" for pipe hanger and support devices. Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Individual, Straight, Horizontal Piping Runs: According to the following:

   a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Division 15 Section "Hangers and Supports."

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 (DN 150): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.

5. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.
6. NPS 15 (DN 375): 60 inches (1500 mm) with 1-inch (25-mm) rod.
7. Spacing for 10-foot (3-m) lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).

G. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

3.7 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.
2. Sump Pumps: To sump pump discharge.

3.8 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 (30 kPa). 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.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 50 psig (345 kPa) 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.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.9 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 15160

SECTION 15181 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes piping, special-duty valves, and hydronic specialties for hot-water heating, chilled-water cooling, snowmelt, and condenser water systems; makeup water for these systems; blowdown drain lines; safety relief vent, and condensate drain piping.

B. Related Sections include the following:

1. Division 7 Section "Through-Penetration Firestop Systems" for materials and methods for sealing pipe penetrations through fire and smoke barriers.
2. Division 7 Section "Joint Sealants" for materials and methods for sealing pipe penetrations through exterior walls.
3. Division 15 Section "Basic Mechanical Materials and Methods" for general piping materials and installation requirements.
4. Division 15 Section "Hangers and Supports" for pipe supports, product descriptions, and installation requirements. Hanger and support spacing is specified in this Section.
5. Division 15 Section "Valves" for general-duty gate, globe, ball, butterfly, and check valves.
6. Division 15 Section "Meters and Gages" for thermometers, flow meters, and pressure gages.
7. Division 15 Section "Mechanical Identification" for labeling and identifying hydronic piping.
8. Division 15 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.
9. Division 15 Section "HVAC Instrumentation and Controls" for temperature-control valves and sensors.

1.3 SUBMITTALS

A. Product Data: For each type of special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing for diverting fittings, and calibrated balancing valves.

B. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Welding Certificates: Copies of certificates for welding procedures and personnel.

D. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

E. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. 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 the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.5 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for foundation wall penetrations.

C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations. Roof specialties are specified in Division 7 Sections.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems" for fire and smoke wall and floor assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Calibrated Balancing Valves:

a. Armstrong Pumps, Inc.
b. Flow Design, Inc.
c. Gerand Engineering Company.
d. Griswold Controls.
e. ITT Bell & Gossett; ITT Fluid Technology Corp.
f. Taco, Inc.

2. Pressure-Reducing Valves:

a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Conbraco Industries, Inc.
d. ITT Bell & Gossett; ITT Fluid Technology Corp.
e. Spence Engineering Company, Inc.
f. Watts Industries, Inc.; Watts Regulators.

3. Safety Valves:

a. ITT Bell & Gossett; ITT Fluid Technology Corp.
b. Amtrol, Inc.
c. Armstrong Pumps, Inc.
d. Conbraco Industries, Inc.
e. Kunkle Valve Division.
f. Spence Engineering Company, Inc.

4. Expansion Tanks:

a. ITT Bell & Gossett; ITT Fluid Technology Corp.
b. Amtrol, Inc.
c. Armstrong Pumps, Inc.
d. Taco, Inc.

5. Air Separators and Air Purgers:

a. ITT Bell & Gossett; ITT Fluid Technology Corp.
b. Amtrol, Inc.
c. Armstrong Pumps, Inc.
d. Taco, Inc.

2.2 PIPING MATERIALS

A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.3 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B).

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).

C. Wrought-Copper Fittings: ASME B16.22.

D. Wrought-Copper Unions: ASME B16.22.

E. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.

2.4 STEEL PIPE AND FITTINGS

A. Steel Pipe, NPS 2 (DN 50) and Smaller: ASTM A 53, Type S (seamless) or Type F (furnace-butt welded), Grade B, Schedule 40, black steel, plain ends.

B. Steel Pipe, NPS 2-1/2 through NPS 12 (DN 65 through DN 300): ASTM A 53, Type E (electric-resistance welded), Grade B, Schedule 40, black steel, plain ends.

C. Steel Pipe, NPS 14 through NPS 18 (DN 350 through DN 450): ASTM A 53, Type E (electric-resistance welded) or Type S (seamless), Grade B, Schedule 30, black steel, plain ends.

1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53, Schedule 40, black steel; seamless for NPS 2 (DN 50) and smaller and electric-resistance welded for NPS 2-1/2 (DN 65) and larger.

D. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250.

E. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.

F. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.

G. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.

H. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

I. 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.

J. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

K. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

2.5 VALVES

A. Gate, globe, check, ball, and butterfly valves are specified in Division 15 Section "Valves."

B. Refer to Part 3 "Valve Applications" Article for applications of each valve.

C. Calibrated Balancing Valves, NPS 2 (DN 50) and Smaller: Bronze body, ball type, 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature, and having threaded ends. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

D. Calibrated Balancing Valves, NPS 2-1/2 (DN 65) and Larger: Cast-iron or steel body, ball type, 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature, and having flanged or grooved connections. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

E. Pressure-Reducing Valves: Diaphragm-operated, bronze or brass body with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.

F. Safety Valves: Diaphragm-operated, bronze or brass body with brass and rubber, wetted, internal working parts; shall suit system pressure and heat capacity and shall comply with the ASME Boiler and Pressure Vessel Code, Section IV.

2.6 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig (1035-kPa) working pressure; 225 deg F (107 deg C) operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 (DN 6) discharge connection and NPS 1/2 (DN 15) inlet connection.

1. Manual air vents shall be as manufactured by:

a. Bell and Gossett - Model No. 17SR.

b. Taco - Model No. 417.

B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and non-ferrous internal parts; 150-psig (1035-kPa) working pressure; 240 deg F (116 deg C) operating temperature; with NPS 1/4 (DN 8) discharge connection and NPS 1/2 (DN 15) inlet connection.

1. Automatic air vents shall be as manufactured by:

a. Bell and Gossett - Model No. 107.
b. Taco - Model Hy-Vent.
c. Armstrong - Model No. AAE-750

C. Diaphragm-Type Expansion Tanks: Welded carbon steel for 125-psig (860-kPa) working pressure, 240 deg F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity, by a flexible, replaceable, elastomeric diaphragm securely sealed into tank. Provide taps for pressure gage and air-charging fitting, and drain fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Provide lift ring. Fabricate and test tank with taps and supports, and label according to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1. Initial Air Pre-Charge: 12 psig.
2. Expansion tanks shall be primed and painted with air dry enamel.

D. Tangential-Type Air Separators: Welded black steel; ASME constructed and labeled for 125-psig (860-kPa) minimum working pressure and 240 deg F maximum operating temperature; perforated stainless-steel air collector tube designed to direct released air into expansion tank; tangential inlet and outlet connections; threaded connections for NPS 2 (DN 50) and smaller; flanged connections for NPS 2-1/2 (DN 65) and larger; threaded blowdown connection. Provide units in sizes for full-system flow capacity.

1. Air separators shall be primed and painted with air dry enamel.
2. Provide base ring suitable for floor mounting.

E. Y-Pattern Strainers: 125-psig (860-kPa) working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for NPS 2-1/2 (DN 65) and larger, threaded connections for NPS 2 (DN 50) and smaller, bolted cover, perforated stainless-steel basket, and bottom drain connection.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot and Chilled Water, 2-Inch NPS (DN50) and Smaller: Aboveground, use Type L (Type B) drawn-temper copper tubing with soldered joints.

B. Hot and Chilled Water, 2-1/2-Inch NPS (DN65) and Larger: Schedule 40, steel pipe with welded and flanged joints.

C. Safety Relief Valve Discharge Piping, 2-Inch NPS (DN50) and Smaller: Aboveground, use Type L (Type B) drawn-temper copper tubing with soldered joints.

D. Safety Relief Valve Discharge Piping, 2-1/2-Inch NPS (DN65) and Larger: Schedule 40, steel pipe with welded and flanged joints.

E. Non-potable Make-up Water Piping, 2-Inch NPS (DN50) and Smaller: Aboveground, use Type L (Type B) drawn-temper copper tubing with soldered joints.

F. Piping between Expansion Tank and Hydronic System, 2-Inch NPS (DN50) and Smaller: Aboveground, use Type L (Type B) drawn-temper copper tubing with soldered joints.

G. Drain Lines: Type L (Type B) drawn-temper copper tubing with soldered joints.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Refer to Division 15 Section "Valves" for valve applications for hydronic systems.

B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

C. Install calibrated balancing valves in the return water line of each heating or cooling element and elsewhere as required to facilitate system balancing.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves on hot-water generators and elsewhere as required by the ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to floor. Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves on hot-water generators and elsewhere as required to regulate system pressure.

3.3 PIPING INSTALLATIONS

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.

B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

D. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

E. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

F. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.

G. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

H. Anchor piping for proper direction of expansion and contraction.

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 15 Section "Hangers and Supports." Comply with requirements below for maximum spacing of supports.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 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.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 3/8 inch (10 mm).
2. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (10 mm).
3. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod size, 1/2 inch (13 mm).
4. NPS 6 (DN 150): Maximum span, 17 feet (5.2 m); minimum rod size, 1/2 inch (13 mm).
5. NPS 8 (DN 200): Maximum span, 19 feet (5.8 m); minimum rod size, 5/8 inch (16 mm).
6. NPS 10 (DN 250): Maximum span, 20 feet (6.1 m); minimum rod size, 3/4 inch (19 mm).

7. NPS 12 (DN 300): Maximum span, 23 feet (7 m); minimum rod size, 7/8 inch (22 mm).

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).

E. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for joint construction requirements for soldered joints in copper tubing; and threaded, welded, and flanged joints in steel piping.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents in mechanical equipment rooms only at high points of system piping, at heat-transfer coils, and elsewhere as required for system air venting.

C. Install air separator in pump suction lines. Install piping to expansion tank with a 2 percent downwardward slope toward tank. Install blowdown piping with ball valve; extend to nearest drain.

D. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches (1200 mm) above floor. Install feeder in bypass line, off main, using globe valves on each side of feeder and in the main between bypass connections. Pipe drain, with ball valve, to nearest equipment drain.

E. Install expansion tanks on floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system design requirements.

1. Support tank from floor with sufficient strength to carry weight of tank, piping connections, and fittings, plus weight of a full tank of water. Do not overload building components and structural members.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be same as for equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If multiple, parallel control valves are installed, only one bypass is required.

D. Install ports for pressure and temperature gages at coil inlet connections.

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 system with clean water. Clean strainers.
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.
2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.
3. Check expansion tanks to determine that they are not air bound and that system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design 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 either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of 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.

3.9 ADJUSTING

A. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

B. Perform these adjustments before operating the system:

1. Open valves to fully open position. Close coil bypass valves.
2. Check pump for proper direction of rotation.
3. Set automatic fill valves for required system pressure.
4. Check 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. Check operation of automatic bypass valves.
7. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.
8. Lubricate motors and bearings.

3.10 CLEANING

A. Flush hydronic-piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing hydronic-piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

END OF SECTION 15181

SECTION 15182 - STEAM AND CONDENSATE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes steam and condensate piping and specialties for systems up to 125 psig (860 kPa), inside the building.

B. Related Sections include the following:

1. Division 15 Section "Basic Mechanical Materials and Methods" for general piping materials and installation requirements.
2. Division 15 Section "Hangers and Supports" for pipe supports, product descriptions, and installation requirements. Hanger and support spacing is specified in this Section.
3. Division 15 Section "Valves" for general-duty gate, globe, ball, butterfly, and check valves.
4. Division 15 Section "Pipe Expansion Fittings and Loops" for expansion joints, product descriptions and installation requirements.
5. Division 15 Section "Meters and Gages" for thermometers, flow meters, and pressure and vacuum gages.
6. Division 15 Section "Mechanical Identification" for labeling and identifying steam and condensate piping.
7. Division 15 Section "HVAC Instrumentation and Controls" for temperature-control valves and sensors.

1.3 DEFINITIONS

A. HP Systems: High-pressure systems operating at 60 psig (414 kPa) or more.

B. MP Systems: Medium-pressure systems operating at 16 psig (110 kPa) to 59 psig (407 kPa).

C. LP Systems: Low-pressure systems operating at less than 15 psig (104 kPa).

D. PLP Systems: Process (clean) low-pressure systems operating at less than 15 psig (104 kPa).

1.4 SYSTEM DESCRIPTION

A. Steam and condensate piping for this Project is a two-pipe, mechanical flow, upfeed system.

1.5 SUBMITTALS

A. Product Data: For each type of special-duty valve and steam trap indicated, including rated capacities and accessories.

B. Shop Drawings: Detail flash tank assemblies and fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, and expansion joints and loops and their attachment to the building structure. Include dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

C. Welding Certificates: Copies of certificates for welding procedures and personnel.

D. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

E. Maintenance Data: For steam traps, vacuum breakers, and meters to include in maintenance manuals specified in Division 1.

1.6 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. 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 flash tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.7 COORDINATION

A. Coordinate layout and installation of steam and condensate piping and suspension system components with other construction, including light fixtures, hydronic piping, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installation for foundation wall penetrations.

C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations. Roof specialties are specified in Division 7 Sections.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems" for fire and smoke wall and floor assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Safety Valves:

   a. Armstrong International, Inc.
   b. Kunkle Inds. Inc.; Kunkle Valve Division.
   c. Spirax Sarco, Inc.
   d. Watts Industries, Inc.; Watts Regulators.
   e. Conbraco Industries, Inc.

2. Pressure-Reducing Valves:

   a. Armstrong International, Inc.
   b. ITT Hoffman; ITT Fluid Technology Corp.
   c. Leslie Controls, Inc.
   d. Spence Engineering Company, Inc.
   e. Spirax Sarco, Inc.

3. Backpressure Valves:

   a. Armstrong International, Inc.
   b. ITT Hoffman; ITT Fluid Technology Corp.
   c. Leslie Controls, Inc.
   d. Spence Engineering Company, Inc.
   e. Spirax Sarco, Inc.

4. Steam Traps:
   a. Spirax Sarco, Inc.

5. Air Vents and Vacuum Breakers:

   a. Armstrong International, Inc.

b. Barnes & Jones, Inc.
c. ITT Hoffman; ITT Fluid Technology Corp.
d. Johnson Corp. (The).
e. Spirax Sarco, Inc.

2.2 PIPING MATERIALS

A. General: Refer to Part 3 piping application articles for applications of pipe and fitting materials.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe, NPS 2 (DN 50) and Smaller: ASTM A 53, Type S (seamless), Grade A, Schedules 40 and 80, black steel, plain ends.

B. Steel Pipe, NPS 2-1/2 through NPS 12 (DN 65 through DN 300): ASTM A 53, Type E (electric-resistance welded), Grade A, Schedules 40 and 80, black steel, plain ends.

C. Steel Pipe, NPS 14 through NPS 18 (DN 350 through DN 450): ASTM A 53, Type E (electric-resistance welded) or Type S (seamless), Grade B, Schedule 30, black steel, plain ends.

D. Steel Pipe, NPS 20 (DN 500): ASTM A 53, Type E (electric-resistance welded) or Type S (seamless), Grade B, Schedule 20, black steel, plain ends.

E. Stainless Steel Pipe, NPS 2 (DN 50) and Smaller: ASTM A 312, Type S (seamless), Grade TP316, Schedules 40 and 80, austenitic stainless steel, plain ends.

F. Stainless Steel Pipe, NPS 2-1/2 through NPS 12 (DN 65 through DN 300): ASTM A 312, Type E (electric-resistance welded), Grade TP316, Schedules 40 and 80, austenitic stainless steel, plain ends.

1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53, Schedules 40 and 80, black steel; seamless for NPS 2 (DN 50) and smaller and electric-resistance welded for NPS 2-1/2 (DN 65) and larger.
2. Stainless Steel Pipe Nipples: ASTM A 733, made of ASTM A 312, Grade TP316, Schedules 40 and 80, austenitic stainless steel; Type S (seamless) for NPS 2 (DN 50) and smaller and Type E (electric-resistance welded) for NPS 2-1/2 (DN 65) and larger.

G. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300.

H. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300.

I. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.

J. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250; raised ground face, and bolt holes spot faced.

K. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

L. Wrought Austenitic Stainless Steel Piping Fittings: ASTM A 403/A 403M, wall thickness to match adjoining pipe.

M. Wrought-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.

N. Wrought Austenitic Stainless 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.

O. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

P. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

2.4 VALVES

A. Gate, globe, check, ball, and butterfly valves are specified in Division 15 Section "Valves."

B. Refer to Part 3 "Valve Applications" Article for applications of each valve.

2.5 SAFETY VALVES

A. Size and Capacity: As required for equipment according to the ASME Boiler and Pressure Vessel Code.

B. Bronze Safety Valves: Class 250, with threaded inlet and outlet; forged copper-alloy disc; fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.

1. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.

C. Cast-Iron Safety Valves: Class 250; forged copper-alloy disc with bronze nozzle; fully enclosed, cadmium-plated steel spring with adjustable pressure range and positive shutoff; raised-face flanged inlet and threaded outlet connections; factory set and sealed.

1. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.

2.6 PRESSURE-REDUCING VALVES

A. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.

B. Valve Characteristics: Pilot-actuated, diaphragm type, with adjustable pressure range and positive shutoff. Valves shall have cast-iron body with threaded connections for valves NPS 2 (DN 50) and smaller and flanged connections for valves NPS 2-1/2 (DN 65) and larger; and hardened stainless-steel trim, replaceable head and seat, main head stem guide fitted with flushing and pressure-arresting device, cover over pilot diaphragm, and non-asbestos gaskets.

2.7 STEAM BACKPRESSURE VALVES

A. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.

B. Valve Characteristics: Pilot-actuated, diaphragm type, with adjustable pressure range and positive shutoff. Valves shall have cast-iron body with threaded connections for valves NPS 2 (DN 50) and smaller and flanged connections for valves NPS 2-1/2 (DN 65) and larger; and hardened stainless-steel trim, replaceable head and seat, main head stem guide fitted with flushing and pressure-arresting device, cover over pilot diaphragm, and non-asbestos gaskets.

2.8 STEAM TRAPS

A. Thermostatic Traps: Class 125, bronze angle-pattern body with integral union tailpiece and screw-in cap; balanced-pressure, stainless-steel or monel bellow element; and renewable, hardened stainless-steel head and seat.

B. Thermodynamic Traps: Stainless-steel body and screw-in cap; maximum operating pressure of 600 psig (4140 kPa); stainless-steel disc and seat; threaded ends.

C. Float and Thermostatic Traps: ASTM A 126, cast-iron body and bolted cap; renewable, stainless-steel float mechanism with renewable, hardened stainless-steel head and seat; maximum operating pressure of 125 psig (860 kPa); balanced-pressure, stainless-steel or monel thermostatic bellow element.

1. Thermostatic air vent capable of withstanding 45 deg F (25 deg C) of superheat and resisting water hammer without sustaining damage.

D. Inverted Bucket Traps: Cast-iron body and cap, pressure rated for 250 psig (1725 kPa); stainless-steel head and seat; stainless-steel valve retainer, lever, and guide pin assembly; and brass or stainless-steel bucket.

1. Strainer: Integral stainless-steel inlet strainer within the trap body.

2. Air Vent: Stainless-steel thermostatic vent.

2.9 THERMOSTATIC AIR VENTS

A. Quick Vents: Cast-iron or brass body, with balanced-pressure, stainless-steel or monel thermostatic bellows and stainless-steel heads and seats.

B. Float Vents: Cast-iron or brass body, seamless brass float, balanced-pressure thermostatic bellows, and replaceable stainless-steel seat, float, and head.

2.10 VACUUM BREAKERS

A. Vacuum Breakers: 150-psig (1035-kPa) steam working pressure, 365 deg F (185 deg C) maximum operating temperature, brass or stainless-steel body, and stainless-steel retainer, spring, and ball; with plain or threaded outlet.

2.11 STRAINERS

A. Y-Pattern Strainers: 250-psig (1725-kPa) working steam pressure; ASTM A 126, Class B cast-iron body; stainless-steel screen, No. 20 mesh for NPS 2 (DN 50) and smaller and manufacturer's recommended perforations for NPS 2-1/2 (DN 65) and larger; tapped blowoff plug. Threaded connections for strainers NPS 2 (DN 50) and smaller and flanged connections for strainers NPS 2-1/2 (DN 65) and larger.

B. Basket Strainers: 250-psig (1725-kPa) working steam pressure; ASTM A 126, Class B cast-iron body; stainless-steel screen; bolted cover; threaded connections for strainers NPS 2 (DN 50) and smaller and flanged connections for strainers NPS 2-1/2 (DN 65) and larger.

2.12 FLASH TANKS

A. Shop or factory fabricated of welded steel according to the ASME Boiler and Pressure Vessel Code, for 150-psig (1035-kPa) rating; and bearing ASME label. Fabricate with tappings for vents, low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety valve, and legs or wall mounting brackets.

2.13 STEAM BLOWDOWN SEPARATORS

A. Shop or factory fabricated of welded steel according to the ASME Boiler and Pressure Vessel Code, for 150-psig (1035-kPa) rating; and bearing ASME label. Fabricate with tappings for vents, condensate outlet, low pressure steam inlet, air vent, and required support.

1. Provide a condensate aftercooler manufactured from Schedule 40 steel pipe with interior baffle and connections for non-potable water inlet and aquastat bulb fitting to measure condensate outlet temperature.

2.14 CONDENSATE COOLER

A. Condensate cooler shall be manufactured from Schedule 40 steel pipe with interior baffle and connections for non-potable water inlet and aquastat bulb fitting to measure condensate outlet temperature.

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS (UP TO 15 PSIG)

A. Steam and Atmospheric Vent Piping, NPS 2 (DN 50) and Smaller: Schedule 40 steel pipe, with threaded joints using Class 125 cast-iron fittings.

B. Steam and Atmospheric Vent Piping, NPS 2-1/2 through NPS 12 (DN 65 through DN 300): Schedule 40 steel pipe, with welded joints using Schedule 40 wrought-steel welding fittings and Class 150 wrought-steel flanges.

C. Condensate and Pumped Discharge Piping, NPS 2 (DN 50) and Smaller: Schedule 80 steel pipe, with threaded joints using Class 125 malleable-iron fittings.

D. Condensate and Pumped Discharge Piping, NPS 2-1/2 through NPS 12 (DN 65 through DN 300): Schedule 80 steel pipe, with welded joints using Schedule 80 wrought-steel welding fittings and Class 150 wrought-steel flanges.

3.2 LPSH PROCESS (CLEAN) STEAM PIPING APPLICATIONS (UP TO 15 PSIG)

A. Steam Piping, NPS 2 (DN 50) and Smaller: Schedule 40 steel pipe, with threaded joints using Class 125 cast-iron fittings.

B. Steam Piping, NPS 2-1/2 through NPS 12 (DN 65 through DN 300): Schedule 40 steel pipe, with welded joints using Schedule 40 wrought-steel welding fittings and Class 150 wrought-steel flanges.

3.3 HP AND MP STEAM PIPING APPLICATIONS (16 PSIG to 125 PSIG)

A. Steam Piping, NPS 2 (DN 50) and Smaller: Schedule 40 steel pipe, with threaded joints using Class 300 malleable-iron fittings.

B. Steam Piping, NPS 2-1/2 through NPS 12 (DN 65 through DN 300): Schedule 40 steel pipe, with welded joints using Schedule 40 wrought-steel welding fittings and Class 150 wrought-steel flanges.

C. Condensate Piping, NPS 2 (DN 50) and Smaller: Schedule 80 steel pipe, with threaded joints using Class 300 malleable-iron fittings.

D. Condensate Piping, NPS 2-1/2 through NPS 12 (DN 65 through DN 300): Schedule 80 steel pipe, with welded joints using Schedule 80 wrought-steel welding fittings and Class 150 wrought-steel flanges.

3.4 LPRH PROCESS (CLEAN) CONDENSATE PIPING APPLICATIONS

A. Condensate and Unfired Steam Generator Blowdown and Drain Piping, All pipe sizes: Schedule 80 stainless steel pipe, with welded joints using Schedule 80 wrought austenitic stainless steel welding fittings and Class 150 wrought austenitic stainless steel flanges.

3.5 VALVE APPLICATIONS

A. General-Duty Valve Applications: Refer to Division 15 Section "Valves" for steam and condensate valve applications.

B. Install shutoff-duty valves at each branch connection to supply mains, at inlet connection to each steam trap, and elsewhere as indicated.

3.6 LP STEAM-TRAP APPLICATIONS (UP TO 15 PSIG)

A. Float and Thermostatic Traps: Steam main and riser drip legs, heat exchangers, and heating coils.

3.7 HP AND MP STEAM-TRAP APPLICATIONS (16 PSIG to 125 PSIG)

A. Inverted Bucket Traps: Steam main and riser drip legs.

B. Thermodynamic Traps: Steam main and riser drip legs.

3.8 PIPING INSTALLATIONS

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.

B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

D. Install steam supply piping at a uniform grade of 0.2 percent downward in direction of steam flow.

E. Install condensate return piping at a uniform grade of 0.4 percent downward in direction of condensate flow.

F. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

G. Unless otherwise indicated, install branch connections to steam mains using 45-degree fittings in main pipe, with the takeoff coming out the top of the main pipe. Use of 90-degree tee fittings is permissible if 45-degree fittings are impractical. If length of branch takeoff is less than 10 feet (3 m), pitch branch line down toward mains at a 0.4 percent grade.

H. Install unions in piping NPS 2 (DN 50) and smaller adjacent to each valve, at final connections of each piece of equipment, and elsewhere as indicated.

I. Install flanges in piping NPS 2-1/2 (DN 65) and larger at final connections of each piece of equipment and elsewhere as indicated.

J. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, traps, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

K. Anchor and guide piping for proper direction of expansion and contraction. Refer to section 15121 where special expansion joint requirements are indicated.

L. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, control valves, isolation valves, pipe bends, and expansion joints.

1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 150 feet where pipe is pitched down in direction of steam flow and a maximum of 75 feet where pipe is pitched up in direction of steam flow.
2. Size drip legs at vertical risers same size as pipe and extend beyond rise. Size drip legs at other locations same diameter as main. In steam mains NPS 6 (DN 150) and larger, dirt leg size can be reduced, but to no less than NPS 4 (DN 100).
3. Install gate valve at drip legs, dirt pockets, and strainer blowdowns to allow removal of dirt and scale.
4. Install steam traps close to drip legs.

M. Pitch condensate piping down toward flash tank. If more than one condensate pipe discharges into flash tank, install a swing check valve in each line. Install thermostatic air vent at top of tank. Install inverted bucket or float and thermostatic trap at low-pressure condensate outlet,

sized for three times the condensate load. Install safety valve at tank top. Install pressure gage, gate valve, and swing check valve, and backpressure valve on low-pressure (flash) steam outlet.

3.9 STEAM-TRAP INSTALLATION

A. Install steam traps in accessible locations as close as possible to connected equipment, but not more than 48 inches (1200 mm) from connected equipment. Coordinate piping layout in order that traps drain properly to condensate pump units or return lines without lifting steam condensate.

1. Unless otherwise indicated, install ball valve, strainer, and union upstream from trap; install union, check valve, and ball valve downstream from trap.

3.10 PRESSURE-REDUCING VALVE INSTALLATION

A. Install pressure-reducing valves in readily accessible location for maintenance and inspection.

B. Install bypass piping around each pressure-reducing valve, with globe valve equal in size to area of pressure reducing valve seat ring, unless otherwise indicated.

C. Install gate valves around each pressure-reducing valve.

D. Install unions around each pressure-reducing valve having threaded-end connections.

E. Install pressure gages on low-pressure side of each pressure-reducing valve and ahead of shutoff valve. Install pressure gages downstream from globe valve on pressure-reducing valve bypass.

1. On two-stage pressure-reducing stations, install drip trap and pressure gage upstream from second stage pressure-reducing valve.

F. Install strainers upstream for each pressure-reducing valve.

G. Install safety valves downstream from each pressure-reducing valve station.

3.11 SAFETY VALVE INSTALLATIONS

A. Install safety valves according to ASME B31.1. Pipe safety valve discharge without valves to atmosphere outside building. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.

3.12 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 15 Section "Hangers and Supports."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 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.

C. Install hangers with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 9 feet (2.7 m); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 1 (DN 25): Maximum span, 9 feet (2.7 m); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1-1/2 (DN 40): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 2 (DN 50): Maximum span, 13 feet (4 m); minimum rod size, 3/8 inch (10 mm).
5. NPS 2-1/2 (DN 65): Maximum span, 14 feet (4.3 m); minimum rod size, 3/8 inch (10 mm).
6. NPS 3 (DN 80): Maximum span, 15 feet (4.6 m); minimum rod size, 3/8 inch (10 mm).
7. NPS 4 (DN 100): Maximum span, 17 feet (5.2 m); minimum rod size, 1/2 inch (13 mm).
8. NPS 6 (DN 150): Maximum span, 21 feet (6.4 m); minimum rod size, 1/2 inch (13 mm).
9. NPS 8 (DN 200): Maximum span, 24 feet (7.3 m); minimum rod size, 5/8 inch (16 mm).
10. NPS 10 (DN 250): Maximum span, 26 feet (8 m); minimum rod size, 3/4 inch (19 mm).
11. NPS 12 (DN 300): Maximum span, 30 feet (9.1 m); minimum rod size, 7/8 inch (22 mm).

D. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.

3.13 PIPE JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for joint construction requirements for threaded, welded, and flanged joints.

3.14 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be same as for equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If multiple, parallel control valves are installed, only one bypass is required.

D. Install vacuum breaker downstream from control valve and bypass and close to coil inlet connection.

E. Install ports for pressure and temperature gages at coil inlet connections.

F. Install a drip leg at coil outlet.

3.15 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Flush system with clean water. Clean strainers.
3. 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.
4. 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 steam and condensate 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.
2. While filling system, use vents installed at high points of system to release trapped air. Use drip legs installed at low points for complete draining of liquid.
3. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design 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 either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."
4. 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.
5. Prepare written report of testing.

3.16 ADJUSTING

A. Mark calibrated nameplates of pump discharge valves after steam and condensate system balancing has been completed, to permanently indicate final balanced position.

B. Perform these adjustments before operating the system:

1. Open valves to fully open position. Close coil bypass valves.
2. Set temperature controls so all coils are calling for full flow.
3. Check operation of automatic bypass valves.

3.17 CLEANING

A. Flush steam and condensate piping with clean water. Remove and clean or replace strainer screens.

END OF SECTION 15182

SECTION 15183 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

B. Related Sections include the following:

1. Division 7 Section "Roof Accessories" for roof curbs, piping supports, and roof penetration boots.
2. Division 7 Section "Through-Penetration Firestop Systems" for materials and methods for sealing pipe penetrations through fire and smoke barriers.
3. Division 7 Section "Joint Sealants" for materials and methods for sealing pipe penetrations through exterior walls.
4. Division 15 Section "Hangers and Supports" for pipe supports and installation requirements.
5. Division 15 Section "Mechanical Identification" for labeling and identifying refrigerant piping.
6. Division 15 Section "Meters and Gages" for thermometers and pressure gages.
7. Division 15 Section "HVAC Instrumentation and Controls" for thermostats, controllers, automatic-control valves, and sensors.

1.3 SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for thermostatic expansion valves, solenoid valves, and 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 relationship between piping and equipment.

1. Refrigerant piping indicated is schematic only. Size piping and design the actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes, to ensure proper operation and compliance with warranties of connected equipment.

C. Welding Certificates: Copies of certificates for welding procedures and personnel.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX; "Welding and Brazing Qualifications."

B. ASHRAE Standard: Comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."

C. ASME Standard: Comply with ASME B31.5, "Refrigeration Piping."

D. UL Standard: Provide products complying with UL 207, "Refrigerant-Containing Components and Accessories, Nonelectrical"; or UL 429, "Electrically Operated Valves."

1.5 COORDINATION

A. Coordinate layout and installation of refrigerant piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for foundation wall penetrations.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

D. Coordinate pipe sleeve installations for penetrations in interior/exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems" for materials and methods for sealing pipe penetrations through fire and smoke barriers.

E. Coordinate pipe fitting pressure classes with products specified in related Sections.

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. Refrigeration Oil Test Kits: two each, containing everything required to conduct one test.
2. Refrigerant: two containers each, with 20 lb (9 kg) of refrigerant.
3. Filter-Dryer Cartridges: three 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:

1. Refrigerants:

a. Allied Signal, Inc./Fluorine Products; Genetron Refrigerants.
b. DuPont Company; Fluorochemicals Div.
c. Elf Atochem North America, Inc.; Fluorocarbon Div.
d. ICI Americas Inc./ICI KLEA; Fluorochemicals Bus.

2. Refrigerant Valves and Specialties:

a. Climate & Industrial Controls Group; Parker-Hannifin Corp.; Refrigeration & Air Conditioning Division.
b. Danfoss Electronics, Inc.
c. Emerson Electric Company; Alco Controls Div.
d. Henry Valve Company.
e. Sporlan Valve Company.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tube: **ASTM B 280, Type ACR**.

B. Annealed-Temper Copper Tube: **ASTM B 280, Type ACR**.

C. Wrought-Copper Fittings: ASME B16.22.

D. Wrought-Copper Unions: ASME B16.22.

E. Bronze Filler Metals: AWS A5.8, Classification **BAg-1 (silver)**

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53, Schedule 40, seamless black steel.

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, butt-welded end connection, and raised face.

D. Flanged Unions: 400-psig (2760-kPa) working pressure, 330 deg F (165 deg C) maximum operating temperature; 2 brass tailpiece adapters for solder-end connections to copper tubing; forged-steel flanges for NPS 1 to NPS 1-1/2 (DN 25 to DN 40) and ductile iron for NPS 2 to NPS 3 (DN 50 to DN 80) with 4 plated-steel bolts, with silicon bronze nuts and fiber gasket; and having factory-applied, rust-resistant coating on flanges and bolts.

E. Flexible Connectors: 500-psig (3450-kPa) operating pressure; seamless tin-bronze or stainless-steel core, high-tensile bronze-braid covering, solder-end connections, and synthetic covering; dehydrated, pressure tested, minimum 7 inches (180 mm) long.

2.4 VALVES

A. Diaphragm Packless Valves: 500-psig (3450-kPa) working pressure and 275 deg F (135 deg C) working temperature; globe design with straight-through or angle pattern; forged-brass or bronze body and bonnet, phosphor bronze and stainless-steel diaphragms, rising stem and handwheel, stainless-steel spring, nylon seat disc, and with solder-end connections.

B. Packed-Angle Valves: 500-psig (3450-kPa) working pressure and 275 deg F (135 deg C) working temperature; forged-brass or bronze body, forged-brass seal caps with copper gasket, back seating, rising stem and seat, molded stem packing, and with solder-end connections.

C. Check Valves Smaller Than NPS 1 (DN 25): 400-psig (2760-kPa) operating pressure and 285 deg F (141 deg C) operating temperature; cast-brass body, with removable piston, polytetrafluoroethylene seat, and stainless-steel spring; globe design. Valve shall be straight-through pattern, with solder-end connections.

D. Check Valves, NPS 1 (DN 25) and Larger: 400-psig (2760-kPa) operating pressure and 285 deg F (141 deg C) operating temperature; cast-bronze body, with cast-bronze or forged-brass bolted bonnet; floating piston with mechanically retained polytetrafluoroethylene seat disc. Valve shall be straight-through or angle pattern, with solder-end connections.

E. Service Valves: 500-psig (3450-kPa) pressure rating; forged-brass body with copper stubs, brass caps, removable valve core, integral ball check valve, and with solder-end connections.

F. Solenoid Valves: Comply with ARI 760; 250 deg F (121 deg C) temperature rating and 400-psig (2760-kPa) working pressure; forged brass, with polytetrafluoroethylene valve seat, 2-way, straight-through pattern, and solder-end connections; manual operator; fitted with suitable NEMA 250 enclosure of type required by location, with 1/2-inch (16-GRC) conduit adapter and [**24**] [**120**]-V, normally [**closed**] [**open**] holding coil.

G. Pressure-Regulating Valves: Comply with ARI 770; pilot operated, forged brass or cast bronze, stainless-steel bottom spring, pressure-gage tappings, 24-V dc standard coil, and wrought-copper fittings for solder-end connections; suitable for refrigerant specified.

H. Pressure-Regulating Valves: Comply with ARI 770; direct acting, brass; with pilot operator, stainless-steel diaphragm, standard coil, and solder-end connection; suitable for refrigerant specified.

I. Pressure Relief Valves: Straight-through or angle pattern, brass body and disc, neoprene seat, and factory sealed and ASME labeled for standard pressure setting.

J. Thermostatic Expansion Valves: Comply with ARI 750; brass body with stainless-steel parts; thermostatic-adjustable, modulating type; size and operating characteristics as recommended by manufacturer of evaporator, and factory set for superheat requirements; solder-end connections; with sensing bulb, distributor having side connection for hot-gas bypass line, and external equalizer line.

K. Hot-Gas Bypass Valve: Pulsating-dampening design, stainless-steel bellows and polytetrafluoroethylene valve seat; adjustable; sized for capacity equal to last step of compressor unloading; with solder-end connections.

2.5 REFRIGERANT PIPING SPECIALITIES

A. Straight- or Angle-Type Strainers: 500-psig (3450-kPa) working pressure; forged-brass or steel body with stainless-steel wire or brass-reinforced Monel screen of 80 to 100 mesh in liquid lines up to 1-1/8 inches (30 mm), 60 mesh in larger liquid lines, and 40 mesh in suction lines; with screwed cleanout plug and solder-end connections.

B. Moisture/Liquid Indicators: 500-psig (3450-kPa) maximum working pressure and 200 deg F (93 deg C) operating temperature; all-brass body with replaceable, polished, optical viewing window with color-coded moisture indicator; with solder-end connections.

C. Replaceable-Core Filter-Dryers: 500-psig (3450-kPa) maximum working pressure; heavy gage protected with corrosion-resistant-painted steel shell, flanged ring and spring, ductile-iron cover plate with steel cap screws; wrought-copper fittings for solder-end connections; with replaceable-core kit, including gaskets and the following:

1. Filter Cartridge: Pleated media with integral end rings, stainless-steel support, ARI 730 rated for capacity.
2. Filter-Dryer Cartridge: Pleated media with solid-core sieve with activated alumina, ARI 730 rated for capacity.
3. Wax Removal Cartridge: Molded, bonded core of activated charcoal and desiccant with integral gaskets.

D. Permanent Filter-Dryer: 350-psig (2410-kPa) maximum operating pressure and 225 deg F (107 deg C) maximum operating temperature; steel shell and wrought-copper fittings for solder-end connections; molded-felt core surrounded by desiccant.

E. Mufflers: 500-psig (3450-kPa) operating pressure, welded-steel construction with fusible plug; sized for refrigeration capacity.

2.6 RECEIVERS

A. Receivers, 6-Inch (150-mm) Diameter and Smaller: ARI 495, UL listed, steel, brazed, 400-psig (2760-kPa) pressure rating, with tappings for inlet, outlet, and pressure relief valve.

B. Receivers Larger Than 6-Inch (150-mm) Diameter: ARI 495, welded steel, tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII; 400-psig (2760-kPa) pressure rating, with tappings for liquid inlet and outlet valves, pressure relief valve, and liquid-level indicator.

2.7 REFRIGERANTS

A. ASHRAE 34, R-22: Monochlorodifluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Aboveground, within Building: **Type ACR drawn-copper tubing Type L**

B. Belowground for NPS 2 (DN 50) and Smaller: **Type ACR** annealed-copper tubing **Type L**.

3.2 VALVE APPLICATIONS

A. Install diaphragm packless or packed-angle valves in suction and discharge lines of compressor, for gage taps at hot-gas bypass regulators, on each side of strainers.

B. Install check valves in compressor discharge lines and in condenser liquid lines on multiple condenser systems.

C. Install packed-angle valve in liquid line between receiver shutoff valve and thermostatic expansion valve for system charging.

D. Install diaphragm packless or packed-angle valves on each side of strainers and dryers, in liquid and suction lines at evaporators, and elsewhere as indicated.

E. Install a full-sized, three-valve bypass around each dryer.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve.

1. Install solenoid valves in horizontal lines with coil at top.
2. Electrical wiring for solenoid valves is specified in Division 16 Sections. Coordinate electrical requirements and connections.

G. Install thermostatic expansion valves as close as possible to evaporator.

1. If refrigerant distributors are used, install them directly on expansion-valve outlet.

2. Install valve so diaphragm case is warmer than bulb.
3. 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.
4. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install pressure-regulating and pressure relief valves as required by ASHRAE 15. Pipe pressure relief valve discharge to outside.

3.3 SPECIALTY APPLICATIONS

A. Install liquid indicators in liquid line leaving condenser, in liquid line leaving receiver, and on leaving side of liquid solenoid valves.

B. Install strainers immediately upstream from each automatic valve, including expansion valves, solenoid valves, hot-gas bypass valves, and compressor suction valves.

C. Install strainers in main liquid line where multiple expansion valves with integral strainers are used.

D. Install strainers in suction line of steel pipe.

E. Install moisture-liquid indicators in liquid lines between filter-dryers and thermostatic expansion valves and in liquid line to receiver.

F. Install pressure relief valves on ASME receivers; pipe discharge to outdoors.

G. Install replaceable-core filter-dryers in vertical liquid line adjacent to receivers and before each solenoid valve.

H. Install permanent filter-dryers in low-temperature systems, in systems using hermetic compressors, and before each solenoid valve.

I. Install solenoid valves in liquid line of systems operating with single pump-out or pump-down compressor control, in liquid line of single or multiple evaporator systems, and in oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into suction line when system shuts down.

J. Install receivers, sized to accommodate pump-down charge, on systems 5 tons (17.5 kW) and larger and on systems with long piping runs.

K. Install flexible connectors at or near compressors where piping configuration does not absorb vibration.

3.4 PIPING INSTALLATION

A. Install refrigerant piping according to ASHRAE 15.

B. Basic piping installation requirements are specified in Division 15 Section "Basic Mechanical Materials and Methods."

C. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

D. Arrange piping to allow inspection and service of compressor and other equipment. Install valves and specialties in accessible locations to allow for service and inspection.

E. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

F. Belowground, install copper tubing in protective conduit. Vent conduit outdoors.

G. Install copper tubing in rigid or flexible conduit in locations where copper tubing will be exposed to mechanical injury.

H. 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.

I. Install bypass around moisture-liquid indicators in lines larger than NPS 2 (DN 50).

J. Install unions to allow removal of solenoid valves, pressure-regulating valves, and expansion valves and at connections to compressors and evaporators.

K. 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.

L. Hanger, support, and anchor products are specified in Division 15 Section "Hangers and Supports."

M. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6.0 m) long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6.0 m) or longer.
3. Pipe rollers for multiple horizontal runs 20 feet (6.0 m) or longer, supported by a trapeze.
4. Spring hangers to support vertical runs.

N. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod size, 1/4 inch (6.4 mm).
4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
5. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
6. NPS 2 (DN 50): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
7. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2700 mm); minimum rod size, 3/8 inch (9.5 mm).
8. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
9. NPS 4 (DN 100): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (13 mm).

O. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1/2 (DN 15): Maximum span, 84 inches (2100 mm); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 3/4 (DN 20): Maximum span, 84 inches (2100 mm); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1 (DN 25): Maximum span, 84 inches (2100 mm); minimum rod size, 1/4 inch (6.4 mm).
4. NPS 1-1/2 (DN 40): Maximum span, 108 inches (2700 mm); minimum rod size, 3/8 inch (9.5 mm).
5. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
6. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 3/8 inch (9.5 mm).
7. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (9.5 mm).
8. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod size, 1/2 inch (13 mm).

P. Support vertical runs at each floor.

3.5 PIPE JOINT CONSTRUCTION

A. Braze joints according to Division 15 Section "Basic Mechanical Materials and Methods."

B. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide) during brazing to prevent scale formation.

3.6 FIELD QUALITY CONTROL

A. Test and inspect refrigerant piping according to ASME B31.5, Chapter VI.

1. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure.
2. Test high- and low-pressure side piping of each system at not less than the lower of the design pressure or the setting of pressure relief device protecting high and low side of system.

    a. System shall maintain test pressure at the manifold gage throughout duration of test.
    b. Test joints and fittings by brushing a small amount of soap and glycerine solution over joint.
    c. Fill system with nitrogen to raise a test pressure of 150 psig (1035 kPa) or higher as required by authorities having jurisdiction.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of the conditioned air 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. Check compressor oil level above center of sight glass.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves, except bypass valves that are used for other purposes.
5. Check compressor-motor alignment, and lubricate motors and bearings.

3.8 CLEANING

A. Before installing copper tubing other than Type ACR, clean tubing and fittings with trichloroethylene.

B. Replace core of filter-dryer after system has been adjusted and design flow rates and pressures are established.

3.9 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter-dryer after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to a vacuum of 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. Provide full-operating charge.

END OF SECTION 15183

SECTION 15185 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following categories of hydronic pumps for hydronic systems:

1. In-line circulators.
2. End-suction pumps.
3. Automatic (cooling coil) condensate pump units.

B. Related Sections include the following:

1. Division 15 Section "Motors" for general motor requirements.
2. Division 15 Section "Mechanical Vibration Controls and Seismic Restraints" for inertia pads, isolation pads, spring supports, and spring hangers.

1.3 SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities; shipping, installed, and operating weights; 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: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Maintenance Data: For pumps to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. UL Compliance: Fabricate and label pumps to comply with UL 778, "Motor-Operated Water Pumps," for construction requirements.

B. Regulatory Requirements: Fabricate and test pumps to comply with HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation," and HI 1.6, "Centrifugal Pump Tests."

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.

D. Pump Pressure Ratings: At least equal to system's maximum operating pressure at point where installed, but not less than specified.

E. Flow tolerance shall be 0 to plus 5% of the ratings for scheduled pressure rating.

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 3 Section "Cast-in-Place Concrete."

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 seal for each pump.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. In-Line Circulators:

   a. Bell & Gossett ITT; Div. of ITT Fluid Technology Corp.

2. Supported-Volute, Flexible-Coupled, End-Suction Pumps:

   a. Bell & Gossett ITT; Div. of ITT Fluid Technology Corp. – Model 1510.

3. Automatic Cooling Condensate Pump Units:

   a. Little Giant Pump Co.

2.2 GENERAL PUMP REQUIREMENTS

A. Pump Units: Factory assembled and tested.

B. Motors: Include built-in, thermal-overload protection and grease-lubricated ball bearings. Select each motor to be nonoverloading over full range of pump performance curve.

C. Motors: Minimum efficiency as indicated in Division 15 Section – "Motors".

2.3 IN-LINE CIRCULATORS

A. Description: Horizontal, in-line, centrifugal, single-stage, bronze-fitted, radially split case design; rated for 125-psig (860-kPa) minimum working pressure and a continuous water temperature of 225 deg F (107 deg C).

1. Casing: Cast iron, with threaded companion flanges for piping connections, and threaded gage tappings at inlet and outlet connections.

   a. Connection Option: Unions at connections for casings that are not available with threaded companion flanges.

2. Impeller: ASTM B 36/B 36M, rolled-temper-brass fabrication, statically and dynamically balanced, closed, overhung, single suction, and keyed to shaft.
3. Shaft and Sleeve: Steel shaft with oil-lubricated copper sleeve.
4. Seals: Mechanical type. Include carbon-steel rotating ring, stainless-steel spring, ceramic seat, and flexible bellows and gasket.
5. Pump Bearings: Oil-lubricated, bronze journal and thrust type.
6. Motor Bearings: Oil-lubricated, sleeve type.
7. Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
8. Motor: Resiliently mounted to pump casing.

2.4 SUPPORTED-VOLUTE, FLEXIBLE-COUPLED, END-SUCTION PUMPS

A. Description: Base-mounted, centrifugal, flexible-coupled, end-suction, single-stage, bronze-fitted, back-pull-out, radially split case design; rated for 175-psig (1200-kPa) minimum working pressure and a continuous water temperature of 225 deg F (107 deg C).

1. Casing: Cast iron, with flanged piping connections, drain plug at low point of volute, threaded gage tappings at inlet and outlet connections, and integral feet or other means on volute to support weight of casing and attached piping. Casing shall allow removal and replacement of impeller without disconnecting piping.
2. Impeller: ASTM B 584, cast bronze, statically and dynamically balanced, closed, over-hung, single suction, keyed to shaft, and secured by locking cap screw.
3. Wear Rings: Replaceable, bronze casing ring.
4. Shaft and Sleeve: Steel shaft with bronze sleeve.
5. Seals: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and flexible bellows and gasket.
6. Coupling: Flexible-spacer type, capable of absorbing torsional vibration and shaft misalignment; with flange and sleeve section that can be disassembled and removed without removing pump or motor.
7. Coupling Guard: Steel, removable, and attached to mounting frame.
8. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate for mounting pump casing, coupling guard, and motor. Field-drill motor-mounting holes for field-installed motors.
9. Motor: Secured to mounting frame, with adjustable alignment.

2.5 PUMP SPECIALTY FITTINGS

A. Suction Diffuser: Angle or straight pattern, 175-psig (1200-kPa) 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- or field-fabricated support.

B. Triple-Duty Valve: Angle or straight pattern, 175-psig (1200-kPa) pressure rating, cast-iron body, pump-discharge fitting; with drain plug and bronze-fitted shutoff, balancing, and check valve features.

2.6 AUTOMATIC COOLING 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- (1800-mm-) minimum, electrical power cord with plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation.

1. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
2. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

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

3.2 PUMP INSTALLATION

A. Install pumps according to manufacturer's written instructions.

1. Install pumps according to HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."

B. Install pumps to provide access for periodic maintenance, including removing motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so piping is not supported by pumps.

D. Suspend in-line pumps using continuous-thread hanger rod and vibration-isolation hangers. Install seismic bracing as required by authorities having jurisdiction and in accordance with Division 15 Section "Mechanical Vibration Controls and Seismic Restraints".

E. Set base-mounted pumps on concrete foundation. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.

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 (19 to 38 mm) 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.

F. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

3.3 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting them on foundations, after grout has been set and foundation bolts have been tightened, and after 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.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 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 the 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 shut-off valves, calibrated balancing valves, check valves, pressure gages, flexible connectors, and pump specialties in locations and in the arrangement as indicated on the Drawings.

F. Install check valve and ball valve on each condensate pump unit discharge.

G. Install electrical connections for power, controls, and devices.

H. Electrical power and control wiring and connections are specified in Division 16 Sections.

I. Ground equipment.

1. 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.

3.5 COMMISSIONING

A. Verify that pumps are installed and connected according to the Contract Documents.

B. Verify that electrical wiring installation complies with manufacturer's written instructions and the Contract Documents.

C. Perform the following preventive maintenance operations and checks before starting:

1. Lubricate bearings.
2. Remove grease-lubricated bearing covers, flush bearings with kerosene, and clean thoroughly. Fill with new lubricant according to manufacturer's written instructions.
3. Disconnect coupling and check motor for proper rotation that matches direction marked on pump casing.

4. Verify that pumps are free to rotate by hand and that pumps for handling hot liquids are free to rotate with pumps hot and cold. Do not operate pumps if they are bound or drag, until cause of trouble is determined and corrected.
5. Check suction piping connections for tightness to avoid drawing air into pumps.
6. Clean strainers.
7. Verify that pump controls are correct for required application.

D. Starting procedure for pumps with shutoff power not exceeding safe motor power is as follows:

1. Prime pumps by opening suction valves and closing drains, and prepare pumps for operation.
2. Open warm-up valves of pumps handling hot liquids if pumps are not normally kept at operating temperature.
3. Open circulating line valves if pumps should not be operated against dead shutoff.
4. Start motors.
5. Open discharge valves slowly.
6. Check general mechanical operation of pumps and motors.
7. Close circulating line valves once there is sufficient flow through pumps to prevent overheating.

E. When pumps are to be started against closed check valves with discharge shutoff valves open, steps are the same, except open discharge valves before starting motors.

F. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for detailed requirements for testing, adjusting, and balancing hydronic systems.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps as specified below:

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining pumps.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15185

SECTION 15186 - STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes condensate pumps for low-pressure steam systems.

B. Related Sections include the following:

1. Division 15 Section "Motors" for general motor requirements for steam condensate pumps.
2. Division 15 Section "Mechanical Vibration Controls and Seismic Restraints" for isolation pads and anchoring requirements.
3. Division 15 Section "Mechanical Vibration Controls" for isolation pads and anchoring requirements.

1.3 SUBMITTALS

A. General: Comply with pertinent provisions of Division 1 Section - "Submittals and Substitutions" and Division 15 Section - "Basic Mechanical Requirements".

B. Product Data: Include certified performance curves and rated capacities of selected models; shipping, installed, and operating weights; furnished specialties; and accessories for each type of product. Indicate pump's operating point on curves. Include receiver capacity and material.

C. Shop Drawings: Show pump layout and connections. Include Setting Drawings with templates for installing foundation and anchor bolts and other anchorages.

1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

D. Coordination Drawings: Comply with pertinent provisions of Division 1 Section - "Special Provisions" and Division 15 Section - "Basic Mechanical Requirements" for Coordination Drawing requirements related to steam condensate pumps.

E. Maintenance Data: List of parts for each type of steam condensate pump and troubleshooting maintenance guide to include in the maintenance manuals specified in Division 1 and Division 15 – "Basic Mechanical Requirements".

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Fabricate and test steam condensate pumps to comply with Hydraulic Institute - HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation," and Hydraulic Institute - HI 1.6, "Centrifugal Pump Tests."

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.

C. ASME Compliance: Fabricate and label receivers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

D. Single-Source Responsibility: Obtain steam condensate return units from one source and by a single manufacturer. Include responsibility and accountability to answer questions and resolve problems regarding compatibility, installation, performance, and acceptance of units.

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 steam condensate 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 3 Section "Cast-in-Place Concrete."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Floor-Mounted, Duplex, Centrifugal Pump, Steam Condensate Return Units:

a. ITT Fluid Handling; Div. of ITT Fluid Technology Corp.
b. Shippensburg Pump Co., Inc. (SHIPCO)
c. Spirax Sarco, Inc.

2.2 GENERAL

A. Description: Factory-fabricated, packaged, electric-drive pump units with capacities indicated on Drawings. Steam condensate pumps shall include receiver, pumps, controls, and accessories suitable for operation with low-pressure steam condensate.

B. Configuration: Floor-mounting, duplex unit with receiver, 2 centrifugal water pumps, and 2 externally adjustable float switches.

2.3 RECEIVER

A. Floor-mounting, close-grained cast iron; with the following features and accessories:

1. Cast iron inlet basket type strainer with self cleaning bronze screen, dirt pocket, and clean-out plug. Inlet strainer shall be mounted on the receiver and screen shall be removable for cleaning.
2. Thermometer well and thermometer.
3. Lifting eye bolts or lugs (minimum of 2).
4. Externally adjustable float switches (2).
5. Flanges for mounting pumps.
6. Water-level gage.

2.4 WATER PUMPS

A. Centrifugal, 2 stage, close coupled, vertical design, permanently aligned, bronze fitted. Include renewable bronze case ring, mechanical seal (rated for 250°F), drip-proof motor with stainless steel shaft and independent pump control circuit for each pump. Pumps shall be mounted on receiver flange. The pumps shall deliver the full specified capacity at all points on the curve with a maximum 2 foot NPSH (net positive suction head) available. Provide the following features and accessories on each pump:

1. Provide a pump suction isolation valve for each pump to allow the entire pump and motor assembly to be removed for service, including the lower half of the pump casing for wear ring replacement, without draining the receiver.

2.5 CONTROL PANEL

A. Control Panel and Wiring: Provide factory mounted and wired NEMA 250, Type 12 control cabinet with hinged door and grounding lug. Provide factory wiring between pumps, float switches, and control panel for single external electrical connection. Wiring to motors, floats,

controls and starters shall be factory run in flexible, liquid tight conduit. The control cabinet shall contain the following:

1. Electrical alternator to sequence water pumps.
2. Manual lead-lag control to override the electric alternator when active pump is manually selected and allows both pumps to operate on receiver high level.
3. The stand-by float switch shall be provided to activate both condensate pumps in the event of failure of the electrical alternator and will sound an alarm in the factory mounted control cabinet.
4. Disconnect switch and cover interlock to insure complete electrical deactivation of the entire condensate handling system.
5. Magnetic starters with fused line protection and overload relays for each pump.
6. Two (2) Hand-Off-Automatic selector switches, with auto spring return from "Hand" position.
7. Control circuit transformer having fused and grounded secondary when motor voltage exceeds 120 volts.
8. Two (2) pump run lights.
9. Numbered terminal strip.
10. Momentary contact "TEST" push button, for each pump, on cover
11. High water alarm light (red).
12. High water alarm horn and silence push button.
13. Contacts to allow high water alarm to be enunciated at building system control panel.

2.6 CONTROL SEQUENCE

A. Control Sequence: Condensate return system controls shall be provided by the unit manufacturer, as follows:

1. When the level in the unit receiver rises to a preset high level, the mechanical alternator shall alternately activate the condensate pumps when the hand-off automatic selector switch is placed in the automatic position.
2. When the pump has discharged the water and the condensate level in the receiver recedes to a preset low level, the alternator shall deactivate and stop the pump.
3. If the condensate level in the receiver should continue to rise to a second high level with the lead pump running; the alternator shall activate the second pump and will continue to operate both pumps until the water level recedes to the preset low level, at which point the pumps shall be deactivated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation.

B. Examine rough installation of steam condensate piping.

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

3.2 STEAM CONDENSATE PUMP INSTALLATION

A. Install pumps according to manufacturer's written instructions.

B. Install pumps to provide access for periodic maintenance, including removing motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so piping is not supported by pumps.

D. Install pumps on concrete bases. Anchor pumps to bases using inserts or anchor bolts in accordance with Division 15 Section "Mechanical Vibration Controls and Seismic Restraints".

E. Install pumps on concrete bases. Anchor units to bases using inserts or anchor bolts in accordance with Division 15 Section "Mechanical Vibration Controls".

F. Install thermometers and pressure gages.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Install shutoff and check valves on inlet of each condensate return connection prior to return header.

D. Install inlet strainer and valved bypass to drain at system return connection.

E. Install union or flange, check valve, throttling valve, and shutoff valve at pump discharge connections for each pump unit.

F. Install pipe drain and overflow to nearest floor drain for overflow and drain piping connections.

G. Install full-size vent piping, terminating in 180-degree elbow at point above highest steam system connection or as indicated on Drawings.

H. Install electrical connections for power, controls, and devices.

I. Electrical power and control wiring and connections are specified in Division 16 Sections.

J. Ground equipment.

1. 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.

3.4 COMMISSIONING

A. Verify that steam condensate pumps are installed and connected according to the Contract Documents.

B. Verify that electrical wiring installation complies with manufacturer's written instructions and the Contract Documents.

C. Complete installation and startup checks according to manufacturer's written instructions.

D. Clean strainers.

E. Set steam condensate pump controls.

F. Set pump controls for automatic start, stop, and alarm operation.

G. Perform the following preventive maintenance operations and checks before starting:

1. Lubricate bearings.
2. Set float switches to operate at proper levels.
3. Set throttling valves on pump discharge for specified flow.
4. Check motors for proper rotation.
5. Test pump controls and demonstrate compliance with requirements.
6. Replace damaged or malfunctioning pump controls and equipment.
7. Verify that pump controls are correct for required application.

H. Start steam condensate pumps according to manufacturer's written startup instructions.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain steam condensate pumps as specified below:

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining pumps.
2. Review data in the "Operating and Maintenance Manuals" specified in Division 1 Section - "Submittals and Substitutions", in Division 1 Section - "Contract Closeout", and Division 15 - "Basic Mechanical Requirements".
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15186

SECTION 15189 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes water-treatment systems for the following:

1. Heating, hot-water systems (closed-loop system).
2. Extension of chilled-water systems in the Central Utility Plant (closed-loop system).
3. Process (clean) steam and condensate piping for humidifiers (open systems).

B. Related Sections include the following:

1. Division 15 Section "Water Softeners" for water treatment in hydronic and steam and condensate piping.

1.3 CHEMICAL FEED SYSTEM DESCRIPTION

A. Closed-Loop System with Water as the Heating or Cooling Medium: One bypass feeder on each system with isolating and drain valves downstream from circulating pumps, unless otherwise indicated.

1. Introduce chemical treatment through bypass feeder when required or indicated by test.

B. Extension of Chilled Water System at the Central Utility Plant: It is the intent of this Section to extend the existing chemical water treatment for the chilled water system in the Central Utility Plant. Extension shall be defined as all work required to maintain current levels of chilled water chemistry including, but not limited to:

1. Introduce system treatment through the bypass feeder located in the Central Utility Plant when required or indicated by test.

C. Process (Clean) Steam and Condensate Piping from Unfired Steam Generators (USG-1): Lead-lag switch controls the sequence of boilers and introduces the chemical to the boiler through a bypass feeder.

1. Chemical feed pump introduces sequestering agent and base from solution tank into unfired steam generator through the associated feedwater line close to each unfired steam

generator, with minimum of one pump per unfired steam generator. Use agitator as required.

2. Pump oxygen scavenger feed from solution tank into unfired steam generator through the associated feedwater line close to each unfired steam generator, with minimum of one pump per unfired steam generator. Use agitator as required.

3. Activate chemical solution pump from meter on makeup water line when unfired steam generator is operating.

4. Liquid-level switch, in each solution tank, deactivates chemical solution pump and signals alarm.

5. Manufacturer supplied timed automatic blowdown system is provided on unfired steam generator. Chemical water treatment provider shall provide analysis of softened and filtered feedwater and shall recommend a setting for the timed blowdown for unfired steam generator.

1.4 PERFORMANCE REQUIREMENTS

A. Maintain water quality for HVAC systems that controls corrosion and build-up of scale and biological growth for maximum efficiency of installed equipment without posing a hazard to operating personnel or the environment.

B. Base chemical treatment performance requirements on 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.

1. Closed-Loop Systems with Water as the Heating or Cooling Medium: Maintain system essentially free of scale, corrosion, and fouling to sustain the following water characteristics:

   a. Hardness: 0.00.
   b. Iron: 0.00.
   c. Total Dissolved Solids (TDS): 1200 to 2000 ppm (as CaCO3).
   d. Silica: 60 ppm or less.
   e. pH: 8.5-9.5
   f. Chemical program designed to maintain a corrosion rate of 5 mpy for steel and 1 mpy for copper.

2. Process (Clean) Steam and Condensate Piping from Unfired Steam Generators (USG-1): Maintain system essentially free of scale, corrosion, total suspended solids, and fouling to sustain the following water characteristics:

   a. Total Alkalinity: 300-500 ppm
   b. pH: 8.0-9.0

c. Sulfite: 30-60 ppm

1.5 SUBMITTALS

A. Product Data: Include rated capacities; water-pressure drops; shipping, installed, and operating weights; and furnished products listed below:

1. Pumps.
2. Chemical solution tanks.
3. Agitators.
4. Control equipment and devices.
5. Test equipment.
6. Chemicals.
7. Filters.
8. Chemical feeders.
9. Water softener system.

B. Shop Drawings: Detail equipment assemblies indicating dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Detail power and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Maintenance Data: For pumps, agitators, filters, system controls, and accessories to include in maintenance manuals specified in Division 1.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of the chemical treatment manufacturer for both installation and maintenance of chemical treatment equipment required for this Project.

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.

1.7 MAINTENANCE

A. Scope of Service: Provide chemicals and service program for maintaining optimum conditions in the circulating water for inhibiting corrosion, scale, and organic growths in the following systems:

1. Heating, hot-water systems (closed-loop system).
2. Extension of chilled-water systems in the Central Utility Plant (closed-loop system).
3. Process (clean) steam and condensate piping for humidifiers (open system).

B. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, including the following:

1. Initial water analysis and recommendations.
2. Startup assistance.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical assistance.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

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. Chemicals: Furnish quantity equal to 25 percent of amount initially installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Provide products by the following:

1. HVAC Water-Treatment Products:

a. Gaurdian Chemical Specialties Corp.

2.2 CHEMICAL FEEDING EQUIPMENT

A. Bypass Feeders: Cast iron or steel, for introducing chemicals into system; with funnel shutoff valve on top, air-release valve on top, drain valve on bottom, and recirculating shutoff valves on sides.

1. Capacity: 5 gal. (19 L).
2. Working Pressure: 125 psig (860 kPa).

B. Positive-Displacement Diaphragm Pump: Simplex, self-priming, rated for intended chemical with 25 percent safety factor for design pressure and temperature.

1. Adjustable flow rate.
2. Thermoplastic construction.
3. Fully enclosed, continuous-duty, 120-V, 60-Hz, single-phase motor.
4. Built-in relief valve.

C. Chemical Solution Tanks: Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with graduated markings.

1. Molded fiberglass cover with recess for mounting pump, agitator, and liquid-level switch.
2. Capacity: 50 gal. (189 L).

D. Agitator: Direct drive, 1750 rpm, mounted on tank with angle adjustment.

1. Fully enclosed, continuous-duty, 120-V, 60-Hz, single-phase motor.
2. Stainless-steel clamp and motor mount, with stainless-steel shaft and propeller.

E. Liquid-Level Switch: Polypropylene housing, integrally mounted PVC air trap, receptacles for connection to metering pump, and low-level alarm.

F. Cold-Water Meter: Positive-displacement type with sealed, tamperproof magnetic drive; impulse contact register; single-pole, double-throw, dry-contact switch.

1. Rotating-disc type with bronze or cast-iron body rated for 125 psig (860 kPa).
2. Magnetic-drive or mechanical-impulse contactor matched to signal receiver.
3. At least six-digit totalizers.
4. 120-V ac.

G. Solenoid Valves: Forged-brass body, globe pattern, and general-purpose solenoid enclosure with 120-V, continuous-duty coil.

H. Chemical Tubing: Schedule 40, PVC with solvent-cement joints; or polypropylene tubing with heat fusion.

I. Plastic Ball Valves: Rigid PVC or CPVC body, integral union ends, and polytetrafluoroethylene seats and seals.

J. Plastic-Body Strainer: Rigid PVC or CPVC with cleanable stainless-steel strainer element.

2.3 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer recommended equipment and chemicals, in a carrying case, for testing pH, total dissolved solids, dissolved oxygen, biocount, chloride, and total alkalinity and for calcium hardness field tests.

2.4 CHEMICALS

A. Furnish chemicals recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment.

B. System Cleaner: Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.

C. Closed-Loop, Water Piping Chemicals: Sequestering agent to reduce deposits and adjust pH, corrosion inhibitors, and conductivity enhancers.

D. Open-Loop Piping Chemicals Serving Humidifiers: Sequestering agent to inhibit scaling, corrosion inhibitor, alkalinity, and oxygen scavenger.

2.5 WATER SOFTENER

A. Manufacturers: Provide products by the following:

1. Water Softener:

a. US Filter Inc. – Series KFZSS/Model 9x40

b. Guardian DT95-16 (dual 4 cubic foot meter activated)

B. Water Softener: Provide a packaged water softener system capable of removing hardness from 19 gallons per minute based on entering water at 10 grains per gallon of total hardness.

1. Provide automatic regeneration controller.
2. Motorized control valve.

2.6 REPLACEABLE CARTRIDGE WATER FILTER

A. Manufacturers: Provide products by the following:

1. Replaceable Cartridge Water Filter:

a. Honeywell Braukmann – Model F76-B102

B. Filtration Unit: 20 micron backwashing filter with 1/2 inch threaded connection brass body, clear plastic sump, stainless steel filter mesh, NBR seals and stainless steel backwash ball valve with serrated discharge outlet.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine the type and quantities of chemical treatment needed to maintain the water quality as specified in "Performance Requirements" Article.

3.2 INSTALLATION

A. Install treatment equipment level and plumb.

B. Add cleaning chemicals as recommended by manufacturer.

C. Add chemicals to each system to meet performance requirements of each system.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Confirm applicable electrical requirements in Division 16 Sections for connecting electrical equipment.

D. Ground equipment.

1. 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.

3.4 FIELD QUALITY CONTROL

A. Engage a factory-authorized service representative to perform startup service.

1. Inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, 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 systems' startup procedures.

B. Test chemical feed piping as follows:

1. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
2. 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.

3. 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.
4. Cap and subject piping to static water pressure of 50 psig (345 kPa) 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.
5. Repair leaks and defects with new materials and retest piping until satisfactory results are obtained.
6. Prepare test reports, including required corrective action.

3.5 ADJUSTING

A. Sample unfired steam generator water at one-week intervals after unfired steam generator startup for a period of five weeks, and prepare certified test report for each required water performance characteristic. Where applicable, comply with ASTM D 3370 and 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.

B. Occupancy Adjustments: Within 12 months of Substantial Completion, perform two separate water analyses to prove that automatic chemical feed systems are maintaining water quality within performance requirements specified in this Section. Perform analyses at least 60 days apart. Submit written reports of water analysis.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.

B. Review manufacturer's safety data sheets for handling of chemicals.

C. Review data in maintenance manuals, especially data on recommended parts inventory and supply sources and on availability of parts and service. Refer to Division 1 Section "Operation and Maintenance Data."

D. Schedule at least four hours of training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15189

SECTION 15194 - FUEL GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes fuel gas piping, specialties, and accessories within the building.

B. Related Sections include the following:

1. Division 2 Section "Natural Gas Distribution" for natural gas service piping, specialties, and accessories outside the building.
2. Division 15 Section "Meters and Gages" for pressure gages.

1.3 PROJECT CONDITIONS

A. Gas System Pressure: One pressure range. **0.5 psig (3.45 kPa).**

B. Design values of fuel gas supplied for these systems are as follows:

1. Nominal Heating Value: 1000 Btu/cu. ft. (37.3 MJ/cu. m).
2. Nominal Specific Gravity: 0.6.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Specialty valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.

B. Shop Drawings: For fuel gas piping. Include plans and attachments to other Work.

C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

D. Maintenance Data: For natural gas specialties and accessories to include in maintenance manuals specified in Division 1.

E. Acceptable Substitute Manufacturers: All bidders desiring to furnish equipment other than that specified must submit a complete verification specification for the substituted equipment along with literature, wiring diagrams, piping diagrams, and a list of similar sized installations where proposed equipment is installed. The complete submittal must be presented to the Architect at least (7) full working days prior to the bid opening for approval. Substitutions will not be permitted after the contract has been awarded. Refer to Specification Section 01300, SUBMITTALS AND SUBSTITUTIONS.

1.5 QUALITY ASSURANCE

A. Electrical Components and Devices: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ANSI Standard: Comply with ANSI Z223.1, "National Fuel Gas Code."

C. FM Standard: Provide components listed in FM's "Fire Protection Approval Guide" if specified to be FM approved.

D. IAS Standard: Provide components listed in IAS's "Directory of A. G. A. and C. G. A Certified Appliances and Accessories" if specified to be IAS listed.

E. UL Standard: Provide components listed in UL's "Gas and Oil Equipment Directory" if specified to be UL listed.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and legally dispose of liquids from drips in existing gas piping. Handle cautiously to avoid spillage and ignition. Notify fuel gas supplier. Handle flammable liquids used by Installer with proper precautions and do not leave on premises from end of one day to beginning of next day.

1.7 COORDINATION

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect'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. Gas Valves, NPS 2 (DN 50) and Smaller:
   a. Jomar International, Ltd.

2. Plug Valves, NPS 2-1/2 (DN 65) and Larger:

   a. Flow Control Equipment, Inc.
   b. Milliken Valve Co., Inc.
   c. Nordstrom Valves, Inc.
   d. Olson Technologies, Inc.; Homestead Valve Div.
   e. Walworth Co.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.3 PIPES, TUBES, FITTINGS, AND JOINING MATERIALS

A. Steel Pipe: ASTM A 53; Type E or S; Grade B; Schedule 40; black.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern, with threaded ends according to ASME B1.20.1.
2. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends according to ASME B1.20.1.
3. Steel Threaded Fittings: ASME B16.11, forged steel with threaded ends according to ASME B1.20.1.
4. Joint Compound and Tape: Suitable for natural gas.

B. Transition Fittings: Type, material, and end connections to match piping being joined.

C. Common Joining Materials: Refer to Division 15 Section "Basic Mechanical Materials and Methods" for joining materials not in this Section.

2.4 PROTECTIVE COATING

A. Furnish pipe and fittings with factory-applied, corrosion-resistant polyethylene coating for use in corrosive atmosphere.

2.5 SPECIALTY VALVES

A. Valves, NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.

B. Valves, NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

PART 3 - EXECUTION

3.1 PREPARATION

A. Close equipment shutoff valves before turning off fuel gas to premises or section of piping. Perform leakage test as specified in "Field Quality Control" Article to determine that all equipment is turned off in affected piping section.

B. Comply with ANSI Z223.1, "Prevention of Accidental Ignition" Paragraph.

3.2 PIPING APPLICATIONS

A. Flanges, unions, transition, and special fittings with pressure ratings same as or higher than system pressure rating may be used in applications below, unless otherwise indicated.

B. Fuel Gas Piping, 0.5 psig (3.45 kPa) or Less: Use the following:

1. NPS 3/4 and NPS 1 (DN 20 and DN 25): Steel pipe, malleable-iron threaded fittings, and threaded joints.

3.3 VALVE APPLICATIONS

A. Piping Line Valves, NPS 2 (DN 50) and Smaller: Gas valve.

3.4 PIPING INSTALLATION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.

B. Concealed Locations: Except as specified below, install concealed gas piping in airtight conduit constructed of Schedule 40, seamless, black steel pipe with welded joints. Vent conduit to outside and terminate with screened vent cap.

1. Above-Ceiling Locations: Gas piping may be installed in accessible spaces, subject to approval of authorities having jurisdiction, whether or not such spaces are used as plenums. Do not locate valves above ceilings.

2. Prohibited Locations: Do not install gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.

a. Exception: Accessible above-ceiling space specified above.

C. Install fuel gas piping at uniform grade of 0.1 percent slope upward toward risers.

D. Connect branch piping from top or side of horizontal piping.

3.5 JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

B. Use materials suitable for fuel gas.

1. Brazed Joints: Make with brazing alloy with melting point greater than 1000 deg F (540 deg C). Brazing alloys containing phosphorus are prohibited.

3.6 HANGER AND SUPPORT INSTALLATION

A. Refer to Division 15 Section "Hangers and Supports" for pipe hanger and support devices.

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).

5. NPS 4 (DN 100) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 5/8 inch (16 mm).

3.7 CONNECTIONS

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

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

3.8 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each specialty valve.
   1. Refer to Division 15 Section "Basic Mechanical Materials and Methods" "Mechanical Identification" for nameplates and signs.

3.9 PAINTING

A. Use materials and procedures in Division 9 Section "Painting," "Exterior Paint Schedule" Article, "Ferrous Metal" Paragraph, "Full-Gloss, Alkyd-Enamel Finish" Subparagraph.

3.10 FIELD QUALITY CONTROL

A. Inspect, test, and purge piping according to ANSI Z223.1, Part 4 "Inspection, Testing, and Purging," and requirements of authorities having jurisdiction.

B. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.

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

D. Verify that specified piping tests are complete.

END OF SECTION 15194

SECTION 15213 - MEDICAL GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes medical gas piping and related specialties for the following medical gas systems:

1. Medical gas pressure systems:

a. Oxygen piping, designated "oxygen."
b. Medical compressed-air piping, designated "medical air."
c. Nitrous oxide piping, designated "nitrous oxide."
d. Nitrogen piping, designated "nitrogen."

2. Medical gas suction systems:

a. Medical-surgical vacuum piping, designated "medical vacuum."
b. Waste anesthetic gas disposal piping, designated "WAGD."

B. Related Sections include the following:
1. Division 15 Section "Meters and Gages" for thermometers and pressure gages.
2. Division 15 Section "Medical Air and Vacuum Equipment" for compressed-air and vacuum equipment and related accessories.

1.3 DEFINITIONS

A. D.I.S.S.: Diameter-index safety system.

B. WAGD: Waste anesthetic gas disposal.

1.4 PERFORMANCE REQUIREMENTS

A. General: Provide medical gas and vacuum piping systems that comply with the following NFPA 99 level categories:

1. Level 1: For entire facility with systems where failure of medical gas supply would be immediate and direct life-safety threat to patients. Air and vacuum equipment arrangement must be duplex or redundant.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Medical gas tubes and fittings.
2. Medical gas manifolds.
3. Medical gas valves and valve boxes.
4. Medical gas service connections and pressure control panels.
5. Medical gas service units. Include integral service connections.
6. Alarm system components.

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

C. Coordination Drawings: For medical gas systems. Include relationship to other services that serve same work area.

D. Brazing Certificates: As required by ASME Boiler and Pressure Vessel Code, Section IX, or AWS B2.2.

E. Piping Material Certification: Signed by Installer certifying that medical gas piping materials comply with NFPA 99 requirements.

F. Certificates of Shop Inspection and Data Report for Bulk Medical Gas Storage Tanks: As required by ASME Boiler and Pressure Vessel Code.

G. Qualification Data: For testing agency.

H. Field quality-control test reports.

I. Operation and Maintenance Data: For medical gas piping and specialties to include in emergency, operation, and maintenance manuals. Include data for the following:

1. Medical gas service connections and pressure control panels.
2. Medical gas service units.
3. Alarm system.
4. Medical gas manifolds.

J. Acceptable Substitute Manufacturers: All bidders desiring to furnish equipment other than that specified must submit a complete verification specification for the substituted equipment along with literature, wiring diagrams, piping diagrams, and a list of similar sized installations where proposed equipment is installed. The complete submittal must be presented to the Architect at least (7) full working days prior to the bid opening for

approval. Substitutions will not be permitted after the contract has been awarded. Refer to Specification Section 01300, SUBMITTALS AND SUBSTITUTIONS.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the Medical Gas Professional Healthcare Organization 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.

B. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASME Compliance: Fabricate and label bulk medical gas storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels."

E. Comply with NFPA 50, "Bulk Oxygen Systems at Consumer Sites."

F. Comply with NFPA 70, "National Electrical Code."

G. Comply with NFPA 99, "Health Care Facilities," for materials and installation.

H. Comply with UL 498, "Attachment Plugs and Receptacles," for electrical service connections.

I. Comply with UL 544, "Medical Equipment," for medical gas specialties.

1.7 COORDINATION

A. Coordinate size and location of concrete bases with concrete work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where 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 PIPES, TUBES, AND FITTINGS

A. Hard Copper Tube: ASTM B 819, Type L, seamless, hard drawn-temper, medical gas tube that has been factory cleaned, purged, and sealed for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and blue for Type L tube.

1. Fittings: Factory cleaned, purged, and bagged for oxygen service according to ASTM B 819 or field cleaned, purged, and bagged as specified in "Preparation" Article in Part 3.

a. Copper Pressure Fittings: ASME B16.22, wrought-copper solder-joint pressure type or MSS SP-73, wrought copper with dimensions for brazed joints.
b. Cast-Copper-Alloy Flanges: ASME B16.24, Class 300.
c. Copper Unions: ASME B16.22 or MSS SP-123.

2.3 JOINING MATERIALS

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for joining materials not in this Section.

B. Brazing Filler Metals: AWS A5.8, BCuP series alloys. Flux is prohibited unless used with bronze fittings.

2.4 MEDICAL GAS VALVES

A. Valves, General: Factory cleaned for oxygen service and bagged.

B. Copper-Alloy Ball Valves: MSS SP-110, 3-piece-body, full-port ball valve rated for 300-psig (2070-kPa) minimum working pressure; with chrome-plated brass ball, PTFE or TFE seats, blowout-proof stem, threaded or solder-joint ends, and locking-type handle designed for quarter turn between opened and closed positions.

1. Manufacturers:

a. Allied Healthcare Products, Inc.; Chemetron Div.
b. Hill-Rom.
c. Jomar International.

C. Bronze Check Valves: Straight-through-pattern, spring-loaded ball check valve; designed for 300-psig (2070-kPa) minimum working pressure.

D. Zone Valves: MSS SP-110, 3-piece-body, full-port copper-alloy ball valve rated for 300-psig (2070-kPa) minimum working pressure; with chrome-plated brass ball, PTFE or TFE seats, blowout-proof stem, threaded or solder-joint ends, and handle designed for quarter turn between opened and closed positions.

1. Include union-type body with bolted swing-away center section.
2. Include factory-installed ASTM B 819, Type K or L, copper-tube extensions with pressure gage for pressure systems and vacuum gage for vacuum systems.
3. Manufacturers:

    a. Hill-Rom: Series 68.
    b. Allied Healthcare Products, Inc.; Chemetron Div. Series 77.

E. Zone Valve Boxes: Formed steel for recessed mounting, with holes for medical gas piping and anchors. Include boxes for single- or multiple-valve installation with pressure gage and in sizes to permit manual operation of valves.

1. Interior Finish: Factory-applied white enamel.
2. Cover Plate: Stainless steel with NAAMM AMP 503, No. 4 finish with frangible or removable windows.
3. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

2.5 MEDICAL GAS MANIFOLDS

A. Manufacturers:

1. Allied Healthcare Products, Inc.; Chemetron Div.
2. Amico Corporation.
3. Beacon Medical Products.
4. Hill-Rom.

B. Description: Manifolds for medical gases that comply with NFPA 99, Ch. 4, Section "Cylinder Systems without Reserve Supply," for high-pressure medical gas cylinders. Include the following features:

1. Central Control Panel Unit: Weatherproof cabinet, supply and delivery pressure gages, electrical alarm system connections and transformer, indicator lights or devices, manifold connection, pressure changeover switch, line-pressure regulator, shutoff valves, and safety valve.
2. Manifold and Headers: Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks. Units include design for minimum 800 psig (5520 kPa inlet pressure. Include cylinder bank headers with inlet (pigtail)

connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.

3. Medical Gas Cylinders: Furnished by Owner (OFCI).
4. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder bank header.
5. Mounting: Wall with mounting brackets for manifold control cabinet and headers or Floor with support legs for manifold control cabinet.
6. Label manifold control unit with permanent label identifying medical gas type and system operating pressure.
7. Nitrous Oxide Manifolds: For 4 cylinders (each side) at 55-psig (380-kPa) line pressure, with electric heater or orifice design that will prevent freezing during high demand.
8. Nitrogen Manifolds: For 4 cylinders (each side) at 200-psig line pressure, with electric heater or orifice design that will prevent freezing during high demand.

2.6 MEDICAL GAS SERVICE CONNECTIONS

A. Connection Devices: For specific medical gas pressure and vacuum services listed. Include roughing-in assemblies, finishing assemblies, and cover plates. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate. Furnish recessed-type units made for concealed piping, unless otherwise indicated.

1. Manufacturers:

    a. Hill-Rom

2. Roughing-in Assembly:

    a. Steel outlet box for recessed mounting and concealed piping.
    b. Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed.
    c. Double seals that will prevent gas leakage.
    d. ASTM B 819, Type K, NPS 3/8 (DN 10) copper inlet or outlet tube brazed to valve with gas-service marking and tube-end dust cap.

3. Finishing Assembly:

    a. Brass housing with primary check valve.
    b. Double seals that will prevent gas leakage.
    c. Cover plate with gas-service label.

4. Quick-Connect Service Connections: With keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of

equipment, and with positive-locking ring that retains equipment stem in valve during use. Include the following:

a. Oxygen Service Connections: Keyed oxygen outlet.
b. Medical Air Service Connections: Keyed medical air outlet.
c. Medical Vacuum Service Connections: Keyed medical vacuum suction inlet.
d. Medical Vacuum Slide Brackets: With pattern matching medical vacuum service connection.

5. Wall Outlet Service Connection Cover Plates: One piece, stainless steel, with NAAMM AMP 503, No. 4 finish and permanent, color-coded, medical gas identifying label matching corresponding outlets.
6. Vacuum Bottle-Slide Brackets: Bottle-slide and mounting assembly matching pattern of vacuum inlet. Include one slide bracket for each wall-mounting vacuum inlet unless no slide bracket requirement is indicated.

2.7 MEDICAL GAS ALARM SYSTEM

A. Manufacturers:

1. Hill-Rom (MedPlus Total Alert/Alarm Network-Master Alarm).

B. Medical Gas Alarm System, General: Compatible alarm panels, remote sensing devices, and other related components as required by NFPA 99 for Level 1 medical gas alarm systems. Refer to Division 15 Section "Medical Air and Vacuum Equipment" for air compressors and vacuum pumps. Power wiring is specified in Division 16 Sections. All alarm conduit and wiring shall be provided under this Section.

C. Components: Designed for continuous service and to operate on power supplied from 120-V ac power source to alarm panels and with connections for 24- or 12-V ac low-voltage wiring and conduit to remote sensing devices by this Section. Include step-down transformers if required.

D. Dew Point Monitors: Hill-Rom Medplus Dew Point/CO Monitor (SIOX) Continuous line monitoring, having panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, factory- or field-installed valved bypass, and visual and cancelable audio signal for dryer site and master alarm panels. Alarm signals when pressure dew point rises above 39 deg F (3.9 deg C) at 55 psig (380 kPa).

E. Pressure and Vacuum Switches: Continuous line monitoring with electrical connections for alarm system.

1. Low-Pressure Switches: 0- to 100-psig (0- to 690-kPa) operating range.
2. High-Pressure Switches: Up to 250-psig (1725-kPa) operating range.
3. Vacuum Switches: 0- to 30-in. Hg (0- to 101-kPa vacuum) range.

F. Carbon Monoxide Monitors: Hill-Rom Medplus Dew Point/CO Monitor (SIOX)Panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, and factory- or field-installed valved bypass. Alarm signals when carbon monoxide level rises above 10 ppm.

G. Medical Gas Alarm Panels: Factory wired with audible and color-coded visible signals to indicate specified functions.

1. Mounting: Recessed installation.
2. Enclosures: Fabricated from minimum 0.047-inch- (1.2-mm-) thick steel or minimum 0.05-inch- (1.27-mm-) thick aluminum, with knockouts for electrical and piping connections.

3. Area Alarm Panels: Series 6819, Separate trouble alarm signals; pressure and vacuum gages; and indicators for oxygen, medical air, and medical vacuum. Alarms signal when the following conditions exist:

   a. Oxygen: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
   b. Medical Air: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
   c. Nitrous Oxide: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
   d. Medical Vacuum: Vacuum drops below 12 in. Hg (40 kPa vacuum).
   e. Nitrogen: Pressure drops below **160 psig (1100 kPa)** or rises above **200 psig (1380 kPa)**.

4. Local Alarm Panels: Series 6819, Separate trouble alarm signals and pressure and vacuum gages to indicate function of medical gas and vacuum equipment. Include alarm signals at local alarm panels when the following conditions exist:

   a. Medical Air Equipment: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), backup air compressor is in operation, pressure drop across filter assembly increases more than 2 psig (13.8 kPa), dew point rises above 39 deg F (3.9 deg C) at 55 psig (380 kPa), carbon monoxide level rises above 10 ppm.
   b. Medical Vacuum Equipment: Vacuum drops below 12 in. Hg (40 kPa vacuum) and backup vacuum pump is in operation.
   c. Nitrogen: Pressure drops below **160 psig (1100 kPa)** or rises above **200 psig (1380 kPa)** secondary in use.
   d. Nitrous Oxide: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), and secondary supply in use.

5. Master Alarm Panels, (MGA-1 & MGA-2): Locate MGA-1 in existing Pavilion A, Telephone Switchboard No. 258 and MGA-2 in existing Maine Building, Security No. 670. Hill-Rom Series 6819 (60-points). Provide master alarm panel with space for existing alarm signals of master alarm panels scheduled to be removed in the

future. Existing switchboard alarm panel to remain. Separate trouble alarm signals, pressure and vacuum gages, and indicators for oxygen, medical air, medical vacuum, nitrous oxide, nitrogen. Unit shall be capable of interfacing with facilities network communications system in the future provided by the Owner. Include alarm signals at master alarm panels when the following conditions exist:

a. Medical Air: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), backup air compressor is in operation, pressure drop across filter assembly increases more than 2 psig (13.8 kPa), dew point rises above 39 deg F (3.9 deg C) at 55 psig (380 kPa), carbon monoxide level rises above 10 ppm.
b. Medical Vacuum: Vacuum drops below 12 in. Hg (40 kPa vacuum) and backup vacuum pump is in operation.
c. Nitrous Oxide: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.
d. Nitrogen: Pressure drops below 160 psig (1100 kPa) or rises above 200 psig (1380 kPa) and changeover is made to alternate bank.

2.8 MEDICAL GAS CYLINDER STORAGE RACKS

A. Wall Storage Racks for Medical Gas Cylinders: Fabricate racks with chain restraints for upright gas cylinders as indicated or provide equivalent manufactured wall racks.

B. Freestanding Storage Racks for Medical Gas Cylinders: Fabricate racks for gas cylinders as indicated or provide equivalent manufactured storage racks.

2.9 TEST GAS

A. Description: Oil-free dry nitrogen complying with CGA P-9, for purging and testing of piping.

2.10 IDENTIFICATION

A. Refer to Division 15 Section "Mechanical Identification" for identification of piping, valves, gages, alarms, and specialties and for labels for bulk medical gas storage tanks.

PART 3 - EXECUTION

3.1 PREPARATION

A. Interruption of Existing Medical Gas Service: Do not interrupt medical gas service to facilities occupied by Owner or others unless permitted under the following conditions and

then only after arranging to provide temporary medical gas service according to requirements indicated:

1. Notify Architect and Owner not less than [two] days in advance of proposed interruption of medical gas service.
2. Do not proceed with interruption of medical gas service without Architect's and Owner's written permission.

B. Cleaning of Piping: If factory-cleaned and -capped medical gas piping is not available or if precleaned piping must be recleaned because of exposure, perform the following procedures:

1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."
2. Wash medical gas piping and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb (0.453 kg) of chemical to 3 gal. (11.3 L) of water.

    a. Scrub to ensure complete cleaning.
    b. Rinse with clean, hot water to remove cleaning solution.

3.2 EARTHWORK

A. Refer to Division 2 Section "Earthwork" for excavating, trenching, and backfilling.

3.3 CONCRETE BASES

A. Install concrete bases for medical air compressor and medical vacuum pump. Cast anchor-bolt inserts into bases. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for concrete bases and to Division 3 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete requirements.

3.4 PIPING APPLICATIONS

A. General: Use pipe, tube, fittings, and joining methods for medical gas piping systems according to the following applications:

B. Joining New to Existing Copper Tubes **NPS 2 (DN 50)** and Smaller: Use memory-metal couplings.

C. Joining of Dissimilar Metal Piping: Use dielectric fittings. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for dielectric fitting types.

1. NPS 2 (DN 50) and Smaller: Use dielectric unions.

2. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.
3. NPS 5 (DN 125) and Larger: Use dielectric flange kits.

D. Specialty and Equipment Flanged Connections: Use cast-copper-alloy companion flange with gasket and brazed joint for connection to copper tube.

E. Interior and Underground Medical Gas Pressure Piping: Use hard copper tube, copper pressure fittings, and brazed joints.

F. Interior Medical Gas Piping at Pressures Greater Than 200 psig (1380 kPa): Use ASTM B 819, Type K, hard copper tube, copper pressure fittings, and brazed joints.

1. Interior Medical Vacuum Piping: Use hard copper tube, copper pressure fittings, and brazed joints.

3.5 MEDICAL GAS VALVE APPLICATIONS

A. Drawings indicate medical gas valve types to be used. If specific valve types are not indicated, the following requirements apply:

1. Medical Gas Pressure Piping:

a. Shutoff Valves NPS 3 (DN 80) and Smaller: Copper-alloy ball valve.
b. Shutoff Valves NPS 4 (DN 100) and Larger: Stainless-steel ball valve.
c. Check Valves NPS 3 (DN 80) and Smaller: Bronze.

2. Medical Vacuum/WAGD Piping:

a. Shutoff Valves NPS 3 (DN 80) and Smaller: Copper-alloy ball valve.
b. Shutoff Valves NPS 4 (DN 100) and Larger: Stainless-steel ball valve.
c. Check Valves NPS 3 (DN 80) and Smaller: Bronze.
d. Check Valves NPS 4 (DN 100) and Larger: Cast iron.

3. Zone Valves: With copper-tube extensions and gage.

3.6 PIPING INSTALLATION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation.

B. Install supports and anchors according to Division 15 Section "Hangers and Supports" with spacing according to NFPA 99.

C. Install thermometers and pressure gages according to Division 15 Section "Meters and Gages."

D. Install flexible pipe connector at each connection to medical air and vacuum equipment.

E. Install exterior, buried medical gas piping in protective conduit fabricated with PVC pipe and fittings. Do not extend conduit through foundation wall.

F. Purge medical gas piping, using oil-free dry nitrogen, after installing piping but before connecting to service connections, alarms, and gages.

3.7 MEDICAL GAS VALVE INSTALLATION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping and valve installation.

B. Install valves in locations required by and according to NFPA 99.

C. Install shutoff valve at each connection to and from medical gas specialties and equipment.

D. Install check valves to maintain correct direction of fluid flow to and from medical gas specialties and equipment.

E. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

F. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.

1. Pressure System Valves: Install pressure gage downstream from valve.
2. Suction System Valves: Install vacuum gage upstream from valve.

G. Install pressure safety and vacuum relief valves where recommended by specialty manufacturers.

H. Install emergency medical gas connections with pressure relief valve and full-size discharge piping to outside, with check valve downstream from pressure relief valve and with ball valve and check valve in supply main from bulk oxygen storage tank.

I. Install pressure regulators in piping to reduce pressure.

J. Install automatic drain valves for specialties and medical air and vacuum equipment that require draining.

3.8 JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

B. Brazed Joints: Use silver- or copper-phosphorus-composition filler metal and comply with CDA's "Copper Tube Handbook," Section VII, "Brazed Joints"; or AWS D10.13, "Recommended Practices for the Brazing of Copper Pipe and Tubing for Medical Gas Systems."

C. Arrange for coupling manufacturer's authorized representative to join new copper tube to existing copper tube with memory-metal couplings.

D. Join new copper tube to existing copper tube with memory-metal couplings. Follow coupling manufacturer's product-specific procedure.

3.9 MEDICAL GAS MANIFOLD INSTALLATION

A. Install medical gas manifolds on concrete base anchored to substrate.

B. Install medical gas cylinders and connect to manifold piping.

C. Install medical gas manifolds with seismic restraints as indicated.

3.10 MEDICAL GAS SERVICE CONNECTION INSTALLATION

A. Install medical gas service connections, of types indicated, in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

B. Install medical gas service connections, of types indicated, in medical gas service units.

3.11 MEDICAL GAS ALARM SYSTEM INSTALLATION

A. Install medical gas alarm system components in locations required by and according to NFPA 99 and manufacturer's written instructions.

B. Install medical gas alarm panels and computer interface cabinet where indicated.

C. Install medical gas anesthetizing-area, area, and master alarm panels.

D. Install medical gas local alarm panels at source equipment.

E. Install computer interface cabinet with connection to medical gas alarm system.

3.12 CONNECTIONS

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

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

C. Connect medical gas piping to specialties, equipment, and accessories.

1. Connection NPS 2 (DN 50) and Smaller: With shutoff valve and copper union.
2. Connection NPS 2-1/2 (DN 65) and Larger: With shutoff valve and cast-copper-alloy flange.

D. Ground specialties and equipment according to Division 16 Section "Grounding and Bonding."

E. Connect wiring according to Division 16 Section "Conductors and Cables."

F. 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.

3.13 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for medical gas piping systems according to NFPA 99. Refer to Division 15 Section "Mechanical Identification" for labeling and identification materials.

B. Captions and Color-Coding: Use the following or similar medical gas captions and color-coding for medical gas piping products where required by NFPA 99:

1. Oxygen: White letters on green background or green letters on white background.
2. Medical Air: Black letters on yellow background.
3. High-Pressure Air: Black letters on yellow background with system pressure indicated.
4. Medical Vacuum: Black letters on white background.
5. Nitrous Oxide: White letters on blue background.
6. Nitrogen: White letters on black background.
7. WAGD: White letters on purple background.

C. Label medical gas systems operating at other-than-standard pressure with system operating pressure.

D. Install continuous detectable underground warning tapes during backfilling of trenches for exterior underground medical gas piping. Locate tapes below finished grade, directly over piping. Refer to Division 2 Section "Earthwork" for underground warning tapes.

3.14 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Testing Agency: Engage a qualified independent 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. Inspect, test, and certify completed medical gas systems according to requirements in NFPA 99. Inspect, test, and certify each medical gas piping system, including specialties, service connections, alarm system, safety devices, and source equipment.

    a. Bulk Oxygen Storage Systems: Comply with NFPA 50.
    b. Bulk Nitrous Oxide Storage Systems: Comply with CGA G-8.1.

2. Provide oil-free dry nitrogen, medical gases, materials, and equipment required for testing.
3. Level 1 Pressure Medical Gas Testing: Use oil-free dry nitrogen, unless otherwise indicated, and perform procedures and tests as indicated in NFPA 99 performance and testing paragraphs for piped gas systems. Include the following:

    a. Performance Testing:

        1) Blow Down: Clear piping before connecting service connections or outlets.
        2) Initial Pressure Tests: Subject each piping section to test pressure of 1.5 times system working pressure, but not less than 150 psig (1035 kPa), before attaching system components, after installing station outlets with test caps (if supplied) in place, and before concealing piping system. Maintain test until joints are examined for leaks by means of soapy water. Repair leaks with new materials and retest systems.
        3) Cross-Connection Tests: Determine that no cross connections of piping systems exist. Disconnect all systems except system to be checked. Pressurize system to 50 psig (345 kPa). Verify that gas flow from service connections and outlets is only from system being checked. Repeat for each system. Verify correct labeling.
        4) Purge Tests: Perform heavy intermittent purging of piping and full-flow purging of service connections.
        5) Standing-Pressure Tests: Install assembled system components after testing individual systems as specified above. Subject systems to 24-hour standing-pressure test at 20 percent above normal line pressure. Verify that pressure differences comply with required calibration. Repair leaks with new materials and retest systems.

    b. System Verification:

        1) Cross-Connection Tests: Repeat cross-connection test above or perform alternate tests with each gas at different pressure.

2) Flow Tests: Perform flow test at each outlet.
3) Valve Tests: Verify proper valve operation.
4) Alarm Tests: Operate systems and verify proper warning indication of each medical gas piping system function.
5) Piping Purity Tests: Test for dew point and hydrocarbons as compared to source gas.
6) Final Tie-End Tests: Verify that above tests have been successfully performed.
7) Operational Pressure Tests: Use designated system gases and test for pressure and flow.
8) Medical Gas Concentration Tests: Test each gas for required concentration.
9) Labeling: Verify correct labeling.

4. Level 1 Vacuum System Testing: Use oil-free dry nitrogen, unless otherwise indicated, and perform procedures and tests as indicated in NFPA 99 performance and testing paragraphs for piped vacuum systems. Include the following:

a. Blow Down: Clear piping before connecting service connections or inlets.
b. Initial Pressure Tests: Subject each piping section to test pressure not less than 150 psig (1035 kPa) before attaching system components, after installing station outlets with test caps (if supplied) in place, and before concealing piping system. Maintain test until joints are examined for leaks by means of soapy water. Repair leaks with new materials and retest systems.
c. Initial Cross-Connection Tests: Determine that no cross connections of piping systems exist. Disconnect all systems except system to be checked. Pressurize system to 50 psig (345 kPa). Verify that gas flow from service connections and outlets is only from system being checked. Repeat for each system. Verify correct labeling.
d. Standing-Pressure Tests: Install assembled system components after testing individual systems as specified above. Subject systems to 24-hour standing-pressure test at not less than 60 psig (415 kPa).
e. Final Cross-Connection Tests: Repeat cross-connection test above or perform alternate tests with each system at different pressure.
f. Vacuum Tests: Verify functional operation of components.
g. Valve Tests: Verify proper valve operation.
h. Alarm Tests: Operate systems and verify proper warning indication of each medical gas piping system function.
i. Labeling: Verify correct labeling.

3.15 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain medical gas alarm system. Refer to Division 1 Section "Closeout Procedures & Demonstration and Training."

END OF SECTION 15213

SECTION 15255 - MEDICAL AIR AND VACUUM EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following medical air and vacuum equipment and related accessories for healthcare facilities:

1. Oil-less, reciprocating medical air compressors and receivers.
2. Air-inlet filters.
3. Desiccant-type dryers and after coolers
4. Compressed-air purification systems.
5. Compressed-air filter assemblies.
6. Waterless air cooled Oil-sealed Liquid Ring medical vacuum pumps and receivers.

B. Related Sections include the following:

1. Division 15 Section "Medical Gas Piping" for compressed-air and vacuum piping, valves, alarms, and related specialties.

1.3 DEFINITIONS

A. Actual Air: Air delivered from air compressors. Flow rate is delivered compressed air measured in acfm (actual L/s).

B. Standard Air: Free air at 68 deg F (20 deg C) and 1 atmosphere (29.92 in. Hg) before compression or expansion and measured in scfm (standard L/s).

1.4 PERFORMANCE REQUIREMENTS

A. Medical air and vacuum equipment shall comply with the following NFPA 99 level categories:

1. Level 1: For entire facility with systems where failure of medical gas supply would be immediate and direct life-safety threat to patients. Compressed-air and vacuum

equipment arrangement must be redundant (duplex). The control panel shall be wired for a future air compressor and vacuum pump (triplex).

1.5 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following medical air and vacuum equipment:

1. Air compressors, including receivers and intake filters.
2. Dessicant-air dryers.
3. Compressed-air purification systems.
4. Compressed-air filter assemblies.
5. Vacuum pumps, including receivers and outlet filters.

B. Shop Drawings: Signed and sealed by a qualified professional engineer.

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
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.

C. Product Certificates: Certificates of shop inspection and data report for receiver tanks as required by ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. Manufacturer Seismic Qualification Certification: Submit certification that medical air and vacuum equipment, accessories, and components will withstand seismic forces defined in Division 15 Section "Mechanical Vibration and Seismic Controls." 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: 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 Installer.

F. Startup service reports. The contractor shall have a manufacturers representative present for start-up and training of the hospital staff.

G. Operation and Maintenance Data: For the following medical air and vacuum equipment and accessories to include in emergency, operation, and maintenance manuals:

1. Air compressors.
2. Dessicant-air dryers.
3. Compressed-air purification systems.
4. Compressed-air filter assemblies.
5. Vacuum pumps.

H. Acceptable Substitute Manufacturers: All bidders desiring to furnish equipment other than that specified must submit a complete verification specification for the substituted equipment along with literature, wiring diagrams, piping diagrams, and a list of similar sized installations where proposed equipment is installed. The complete submittal must be presented to the Architect at least (7) full working days prior to the bid opening for approval. Substitutions will not be permitted after the contract has been awarded. Refer to Specification Section 01300, SUBMITTALS AND SUBSTITUTIONS.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative of medical air and vacuum equipment manufacturer for both installation and maintenance of units required for this Project.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of medical air and vacuum equipment and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASME Compliance: Fabricate and label receiver tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. Comply with NFPA 70, "National Electrical Code."

F. Comply with NFPA 99, "Health Care Facilities," for materials and installation.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for concrete bases. Refer to Division 3 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where 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 PACKAGED MEDICAL AIR COMPRESSORS AND RECEIVERS

A. Description: Factory-assembled, pre-wired, pre-piped, and pre-tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air. Control panel shall be wired for a future third compressor installation.

B. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.

1. Mounting and Wiring: Factory installed and connected as an integral part of equipment package.
2. Enclosure: NEMA ICS 6, Type 12 control panel, unless otherwise indicated.
3. Motor Controllers: Full-voltage, combination-magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.

    a. Control Voltage: 120-V ac or less, using integral control power transformer.
    b. Motor Overload Protection: Overload relay in each phase.
    c. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.

        1) Automatic control switches to sequence lead-lag compressors for multiplex air compressors.

4. Instrumentation: Include receiver pressure gage, discharge-air pressure gage, air-filter maintenance indicator, hour meter, compressor discharge-air and coolant temperature gages, and control transformer.
5. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.

C. Motors: General requirements for motors are specified in Division 15 Section "Motors."

1. 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.

D. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; rated for working pressure at least as high as highest discharge pressure of connected compressors; and bearing appropriate code symbols. Include safety valve, pressure gage, automatic drain, and pressure-reducing valve.

E. Fabricate base and attachment to pressure vessel with reinforcement strong enough to resist packaged equipment movement during a seismic event when base is anchored to building structure.

2.3 RECIPROCATING MEDICAL AIR COMPRESSORS

A. Manufacturers:

1. EMSE Corporation. Model No. 3TOC15B200E.
2. Beacon Medical.

B. Description: Duplex, reciprocating-type, medical air compressor unit. The control–panel shall be wired for a future third compressor.

1. Compressor(s): Heavy duty oil-less reciprocating air-cooled design with totally dry crankcase and piston rings and guides of high quality DuPont heat-resistant PTFE (Teflon) material. The compressors shall have long wearing heavey duty cast iron deep finned cylinders. Pistons shall be protected by a heat barrier for extended ring and piston pin bearing life (10,000 hours). Main shaft bearings shall have 20,000 hours service life. Cooling shall be provided by built-in industrial grade fan. Each compressor shall be equipped with hour meter, spring type vibration isolators and enclosure.

a. Mounting: mounted on a common structural steel stack base.
b. Number of Compressors: Two w/space for future third compressor.
c. Motor Size (Each Compressor): 10 hp, 1750 rpm, 460 volt, 3 phase, 60 Hz.

1) Full-Load Amperes:
2) Minimum Circuit Ampacity:
3) Maximum Overcurrent Protection: A.

d. Standard-Air Capacity of Each Air Compressor: 69.0 scfm standard L/s) free air.
e. Discharge Air Pressure: 100 **psig (690 kPa)**] .
f. High discharge-air temperature switch.
g. Belt guards totally enclosing pulleys and belts.
h. Intercoolers between stages of two-stage units.

2. Receiver: ASME construction steel tank with **stainless steel lining.**

a. Orientation: Vertical arrangement.
b. Capacity: 200 gal.
c. Pressure Rating: **125 psig (860 kPa)**] minimum.

3. Miscellaneous Devices: Safety valves, discharge-air pressure gages, pressure regulators, 3-way by-pass, gauge glass, automatic electronic tank drain w/manual override, shutoff valves, and durable stainless steel lining.

2.4 AIR-INLET FILTERS

A. Description: Combination inlet filter-silencer, suitable for remote installation, for each air compressor.

1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
2. Capacity: Match capacity of air compressor, with collection efficiency of 99 percent retention of particles larger than 10 microns.

2.5 COMPRESSED-AIR DRYERS

A. Duplex Desiccant-Type Dryers: Twin-tower unit with purge system, mufflers, and capability to deliver plus 10° deg F (minus 12 deg C), 100-psig (690-kPa)] air at dew point. Include dew point controlled purge, step-down transformers and disconnect switches, inlet and outlet pressure gages, thermometers, automatic controls, and filters.

1. Manufacturers:

a. EMSE Corporation. Model No. 3DDF75.
b. Beacon Medical.

2. Capacity: Match maximum capacity of connected air compressor.
3. Pre-Filter: dual 0.5-micron.
4. After-Filter: dual 0.5-micron.

B. All components shall be pre-piped and pre-wired to single point service connections in field. Each unit consists of two identical banks of air treatment equipment, piped in par-

allel and provided with valves to by-pass either filter set for element replacement, maintenance and repair on one of the sets while still treating medical compressed air through the other set without any sacrifice in air quality. Each bank shall consist of three stages of treatment.

C. First Stage: Provide a prime efficiency coalescer with particle removal down to 0.5 micron. Maximum downstream remaining oil content 0.5 PPM/WT. Retention on DOP test >99.97%. This filter removes aerosols and solid particles.

D. Second Stage: Desiccant heatless air dryer, equipped with purge control. Pressure dewpoint of +10 deg. F.

E. Third Stage: Prime efficiency particle after filter with particle removal down to 0.5 micron.

F. Downstream pressure regulators to maintain constant discharge pressure of 50 PSIG plus or minus 10%.

G. Digital dew point and CO monitors with alarm points set at +39° deg F and 10 PPM provided with dry contacts to remote alarm panels. Provide a demand check as required by NFPA 99 for each monitor.

H. A factory trained representative shall check installation, provide start-up, and instruct personnel to ensure proper operation and maintenance.

I. The Plumbing Contractor shall coordinate with the HVAC Contractor to ensure the ambient room temperature shall not exceed 90° F for the medical air plant.

2.6 MEDICAL VACUUM PUMPS

A. Manufacturers:
   1. EMSE Corporation.
   2. Beacon Medical.

B. Description: **Duplex**, liquid-ring-type, medical vacuum pump unit for **medical vacuum** systems. System shall be wired for future compressor (triplex).

   1. Vacuum Pump(s): Nonpulsating, rotary, liquid-ring type.

      a. Construction: Cast-iron body and rotor, cast-iron body with bronze rotor, or bronze body and rotor.
      b. Mounting: **Freestanding.**
      c. Number of Vacuum Pumps: **Two.** (Wired for Future Third Pump).
      d. Motor Size (Each Vacuum Pump): 10 hp, **1750** rpm, **3** phase, 60 Hz.

         1) Full-Load Amperes:

2) Minimum Circuit Ampacity:
3) Maximum Overcurrent Protection: A.

e. Standard-Air Capacity of Each Vacuum Pump: 60.9 scfm free air.
f. Vacuum Produced: [**26 in. Hg (88 kPa vacuum**)].
g. Coupling: Nonlubricated, flexible type.
h. Sealing Fluid: SAE 30 automotive oil recirculating four stage separation.
i. Outlet silencers on discharge connections.

2. Receiver: ASME construction steel tank with stainless steel lining.

a. Orientation: **Vertical** arrangement.
b. Capacity: 200 gal.
c. Pressure Rating: 200 **psig (690 kPa)** minimum and suitable for vacuum produced by vacuum pump(s).

3. Miscellaneous Devices: Safety valves, inlet-line vacuum gages, and shutoff valves

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean equipment, accessories, and components that have not been cleaned for oxygen service and sealed or that are furnished unsuitable for medical applications, according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."

3.2 CONCRETE BASES

A. Install concrete bases for medical air and vacuum equipment. Concrete base is specified in Division 15 Section "Basic Mechanical Materials and Methods," and concrete materials and installation requirements are specified in Division 3.

3.3 EQUIPMENT INSTALLATION

A. Install medical air and vacuum equipment according to NFPA 99.

B. Install medical air and vacuum equipment on concrete bases. Set and connect units according to manufacturers' written instructions. Install units level, plumb, and anchored to substrate in locations indicated. Maintain manufacturers' recommended clearances. Orient equipment so controls and devices are accessible for servicing.

1. Anchor packaged equipment to concrete base according to manufacturers' written instructions and seismic criteria applicable to Project.

a. 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.
b. Install epoxy-coated anchor bolts for supported equipment; extend through concrete base and anchor into structural concrete floor.
c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
d. Install anchor bolts to elevations required for proper attachment to supported equipment.
e. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

C. Vibration Isolation: Install **spring** isolators with 2% deflection. Vibration isolation devices and installation requirements are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

D. Vibration Isolation: Mount equipment on a vibration isolation equipment base as specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Install the following devices on medical air equipment:

1. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
2. Pressure Regulators: Install downstream from air compressors, dryers, purification units, and filter assemblies.
3. Automatic Drain Valves: Install on intercoolers, aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.

G. Install the following devices on medical vacuum equipment:

1. Thermometer, Vacuum Gage, and Vacuum Relief Valve: Install on each vacuum receiver **and separator.**
2. Automatic Drain Valves: Install on vacuum receiver tanks **and separators.** Discharge condensate over nearest floor drain.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Connect piping to compressors, vacuum pumps, and receivers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connec-

tors and their installation are specified in Division 15 Section "Basic Mechanical Materials and Methods."

D. Connect medical air and vacuum equipment to **medical** gas alarm system. Refer to Division 15 Section "Medical Gas Piping" for alarm system.

E. Ground equipment according to Division 16 Section "Grounding and Bonding."

F. Connect wiring according to Division 16 Section "Conductors and Cables."

G. 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.

3.5 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for medical air and vacuum equipment according to NFPA 99. Refer to Division 15 Section "Mechanical Identification" for labeling and identification materials.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to test, inspect, and adjust components and equipment installation and to perform startup service.

B. Perform the following final checks:

1. Verify that specified tests of piping systems are complete.
2. Verify that potable-water supply connections to equipment have correct backflow preventer.
3. Check for piping connection leaks.
4. Check for lubricating oil in lubricated-type equipment.
5. Check belt drives for proper tension.
6. Verify that air compressor inlet filters and piping are clear.
7. Verify that vacuum equipment filters and piping are clear.
8. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
9. Check safety valves for correct settings. Ensure that settings are greater than air compressor discharge pressure but not greater than rating of system components.
10. Check vacuum relief valves for correct settings.
11. Check for proper seismic restraints.
12. Test operation of equipment safety controls and devices.
13. Drain receiver tanks.
14. Drain separators and add disinfectant.

C. Verify that medical air and vacuum equipment is installed and connected according to the Contract Documents.

D. Verify that electrical wiring installation complies with manufacturer's submittal and written installation requirements in Division 16 Sections.

E. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

F. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

G. Complete installation and startup checks according to manufacturer's written instructions.

H. Prepare written report documenting testing procedures and results.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain medical air and vacuum equipment. Refer to Division 1 Section "**Contract Closeout.**"

END OF SECTION 15255

SECTION 15410 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes plumbing fixtures and related components.

B. Related Sections include the following:

1. Division 15 Section "Emergency Plumbing Fixtures."
2. Division 15 Section "Security Plumbing Fixtures."
3. Division 15 Section "Drinking Fountains and Water Coolers."
4. Division 15 Section "Plumbing Specialties" for backflow preventers and specialty fixtures not in this Section.

1.3 DEFINITIONS

A. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Fitting: Device that controls flow of water into or out of 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: Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports and indicate materials and finishes, dimensions, construction details, and flow-control rates for each type of fixture indicated.

B. Shop Drawings: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Maintenance Data: For plumbing fixtures to include in maintenance manuals specified in Division 1.

D. Acceptable Substitute Manufacturers: All bidders desiring to furnish equipment other than that specified must submit a complete verification specification for the substituted equipment along with literature, wiring diagrams, piping diagrams, and a list of similar sized installations where proposed equipment is installed. The complete submittal must be presented to the Architect at least (7) full working days prior to the bid opening for approval. Substitutions will not be permitted after the contract has been awarded. Refer to Specification Section 01300, SUBMITTALS AND SUBSTITUTIONS.

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"; about plumbing fixtures for people with disabilities.

D. Regulatory Requirements: Comply with requirements in U.S. Architectural & Transportation Barriers Compliance Board's "Uniform Federal Accessibility Standards (UFAS), 1985-494-187" about plumbing fixtures for people with disabilities.

E. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

F. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

G. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

H. Comply with the following applicable standards and other requirements specified for plumbing fixtures:

1. Hand Sinks: NSF 2 construction.
2. Slip-Resistant Bathing Surfaces: ASTM F 462.
3. Stainless-Steel Fixtures: ASME A112.19.3M.
4. Vitreous-China Fixtures: ASME A112.19.2M.

5. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.
6. Water-Closet, Flushometer Tank Trim: ASSE 1037.

I. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:

1. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
2. Faucets: ASME A112.18.1M.
3. Hose-Connection Vacuum Breakers: ASSE 1011.
4. Hose-Coupling Threads: ASME B1.20.7.
5. NSF Materials: NSF 61.
6. Pipe Threads: ASME B1.20.1.
7. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
8. Supply and Drain Fittings: ASME A112.18.1M.

J. Comply with the following applicable standards and other requirements specified for shower faucets:

1. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
2. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.
3. Faucets: ASME A112.18.1M.
4. Hand-Held Showers: ASSE 1014.
5. High-Temperature-Limit Controls for Thermal-Shock-Preventing Devices: ASTM F 445.
6. Hose-Coupling Threads: ASME B1.20.7.
7. Manual-Control Antiscald Faucets: ASTM F 444.
8. Pipe Threads: ASME B1.20.1.
9. Pressure-Equalizing-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
10. Thermostatic-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.

K. 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 A112.18.1M.
3. Manual-Operation Flushometers: ASSE 1037.
4. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.
5. Tubular Brass Drainage Fittings and Piping: ASME A112.18.1M.

L. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Floor Drains: ASME A112.21.1M.
2. Grab Bars: ASTM F 446.
3. Hose-Coupling Threads: ASME B1.20.7.

4. Hot-Water Dispensers: ASSE 1023 and UL 499.
5. Off-Floor Fixture Supports: ASME A112.6.1M.
6. Pipe Threads: ASME B1.20.1.
7. Plastic Toilet Seats: ANSI Z124.5.
8. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 COORDINATION

A. Coordinate roughing-in and final plumbing fixture locations, and verify that fixtures can be installed to comply with original design and referenced standards.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. For fixture descriptions in other Part 2 articles where the subparagraph titles Products and Manufacturers introduce a list of manufacturers and their products or manufacturers only, the following requirements apply for product selection:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the products specified in other Part 2 articles.
2. Products: Subject to compliance with requirements, provide one of the products specified in other Part 2 articles.
3. 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 in other Part 2 articles.
4. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified in other Part 2 articles.

2.2 LAVATORY FAUCETS

A. Lavatory Faucet, L-1, L-2 & L-3: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes and outlet with spout and fixture receptor.

1. Products:

   a. Chicago Faucet, Co.: No. 786-5-XK-FC.

2. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
3. Body Material: Cast brass.
4. Finish: Polished chrome plate.
5. Type: Two-handle mixing.

6. Centers: 8 inches (203 mm)].
7. Mounting: Deck.
8. Handle(s): Wrist blade, 6 inches (100 mm).
9. Inlet(s): NPS 3/8 (DN 10) tubing, with NPS 1/2 (DN 15) male adaptor.
10. Spout: Model GN2A Interchangable Rigid/Swing.
11. Spout Outlet: Plain end.
12. Operation: Noncompression, manual.
13. Drain: Model 337-1-1/4-inch Grid.
14. Tempering Device: Not required.

2.3 SHOWER FAUCETS

A. Shower Faucet, SH-1, SH-2 & SH-3: Include hot- and cold-water indicators; and shower head, arm, and flange. Coordinate faucet inlets with supplies and outlet with diverter valve.

1. Manufacturers:

   a. Symmons, Co.: 1-117VT-FS-X-2 Safetymix Visu-Temp.

2. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
3. Body Material: Cast brass.
4. Finish: Polished chrome plate.
5. Type: Single-handle pressure balance with integral or field-installed check stops on hot- and cold-water supplies.
6. Mounting: Concealed.
7. Handle[s]: Lever.
8. Diverter Valve: Not integral with mixing valve.
9. Backflow Protection Device for Hand-Held Shower: In-line vacuum breaker.
10. Operation: Compression, manual.
11. Antiscald Device: Integral with mixing valve.
12. Supply Connections: NPS 1/2 (DN 15), Sweat.
13. Shower Head Material: Metallic with chrome-plated finish.
14. Stationary Head Type: Model 4-143 Ball joint.
15. Handspray: Model H323, 5-feet Hand held, 30-inch adjustable slide-bar mounted.
16. Spray Pattern: 3-mode-Full, pulsating and soft.
17. Integral Volume Control: Required.
18. Shower-Arm, Flow-Control Fitting: 1.5 gpm (5.7 L/min.).

2.4 SINK FAUCETS

A. Sink Faucet, SK-1, SK-2, SK-6 & SK-7: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes and outlet with spout and fixture receptor.

1. Available Manufacturers:
2. Manufacturers:

    a. Chicago Faucet. 786-FC-XK combination faucet with GN2FC.

3. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
4. Body Material: Cast brass.
5. Finish: Polished chrome plate.
6. Type: Faucet with three-hole fixture.
7. Mixing Valve: 319, Two-lever handle.
8. Backflow Protection Device for Hose Outlet: Not required.
9. Centers: 8 inches (203 mm)] Single hole.
10. Mounting: Deck.
11. Handle[s]: Wrist blade, 6 inches (150 mm)].
12. Inlet[s NPS 3/8 (DN 10) tubing with NPS 1/2 (DN 15) male adapter.
13. Spout: Interchangable Rigid/Swing.
14. Spout Outlet: Plain end.
15. Vacuum Breaker: Not required.
16. Operation: Compression, manual.
17. Drain: Grid.
18. Tempering Device: Not required.

B. Sink Faucet, SK-3: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes and outlet with spout and fixture receptor.

1. Available Manufacturers:
2. Manufacturers:

    a. Chicago Faucet. 2300.

3. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
4. Body Material: Cast brass.
5. Finish: Polished chrome plate.
6. Type: Faucet with three-hole fixture.
7. Mixing Valve: One-lever handle.
8. Backflow Protection Device for Hose Outlet: Not required.
9. Centers: 8 inches (203 mm) Single hole.
10. Mounting: Deck.
11. Handle[s]: Single lever.
12. Inlet[s: NPS 3/8 (DN 10) tubing with NPS 1/2 (DN 15) male adapter.
13. Spout: Swing, cast
14. Spout Outlet: Aerator.
15. Vacuum Breaker: Not required.
16. Operation: Compression, manual.
17. Drain: Grid.
18. Tempering Device: Not required.

C. Sink Faucet, SK-4, SK-5, SK-8 & SK-9: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes and outlet with spout and fixture receptor.

1. Manufacturers:

   a. Chicago Faucet. 652-FC-8-123 with GN2AH8.

2. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
3. Body Material: Cast brass.
4. Finish: Polished chrome plate.
5. Type: Faucet with three-hole fixture.
6. Mixing Valve: Adjustable temperature control.
7. Backflow Protection Device for Hose Outlet: Not required.
8. Centers: 8 inches (203 mm)] Single hole.
9. Mounting: Deck.
10. Handle[s]: Infra-red sensor.
11. Inlet[s [NPS 3/8 (DN 10) tubing with NPS 1/2 (DN 15) male adapter
12. Spout: GN2AH8 Rigid gooseneck.
13. Spout Outlet: Plain end w/flow control.
14. Vacuum Breaker: Not required.
15. Operation: Electronic w/infrared sensor and hardwire transformer.
16. Hard-Wire Transformer: Mount transformer above ceiling to junction box provided by Div. 16. Run 22AWG wire concealed in wall to sensor panel under sink. Mount sensor panel to keep conduit tight to underside of fixture out of sight.
17. Drain: Grid.
18. Tempering Device: Deck mount.
19. Electrical: 120 VAC, 15 AMP GFI circuit. Coordinate w/Div. 16.

D. Sink Faucet, MSB-1: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes and outlet with spout and fixture receptor.

1. Manufacturers:

   a. Chicago Faucet. 445-897S-RC-XK.

2. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
3. Body Material: Cast brass
4. Finish: Polished chrome plate.
5. Type: Service sink faucet with stops in shanks, vacuum breaker, hose-thread outlet, and pail hook.
6. Mixing Valve: Two-lever handle.
7. Backflow Protection Device for Hose Outlet: Required.
8. Centers: 8 inches (203 mm)] Single hole.
9. Mounting: Back/wall, exposed.
10. Handle[s]: Wrist blade, 4 inches (100 mm)].
11. Inlet[s]: NPS 1/2 (DN 15) male shank.

12. Spout: Rigid, cast
13. Spout Outlet: Hose thread.
14. Vacuum Breaker: Required.
15. Operation: Compression, manual.
16. Drain: Grid.
17. Tempering Device: Not required.

E. Sink Faucet, SS-1 & SS-2: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes and outlet with spout and fixture receptor.

1. Refer to Section 2.17.

F. Sink Faucet, CSS-1: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes and outlet with spout and fixture receptor.

1. Manufacturers:

a. Chicago Faucet. 814-NCP-90090

2. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
3. Body Material: [Cast brass].
4. Finish: Polished chrome plate.
5. Type: Service sink faucet with stops in shanks, vacuum breaker, hose-thread outlet, and pail hook.
6. Mixing Valve: Two-lever handle.
7. Backflow Protection Device for Hose Outlet: Required.
8. Centers: 8 inches (203 mm)] Single hole.
9. Mounting: Back/wall, exposed].
10. Handle[s]: Wrist blade, 4 inches (100 mm)].
11. Inlet[s]: NPS 1/2 (DN 15) male shank.
12. Spout: Rigid, cast With wall brace.
13. Spout Outlet: Hose thread.
14. Vacuum Breaker: Required .
15. Operation: Compression, manual].
16. Drain: Not required.
17. Tempering Device: Not required.

2.5 FLUSHOMETERS

A. Flushometer, WC-1 & WC-2: Cast-brass body with corrosion-resistant internal components,[non-hold-open feature,] control stop with check valve, vacuum breaker, and copper or brass tubing, and polished chrome-plated finish on exposed parts.
1. Manufacturers:

a. Sloan Royal. 111-1.6

2. Internal Design: Diaphragm operation.
3. Style: Exposed.
4. Inlet Size: NPS 1 (DN 25).
5. Trip Mechanism: Oscillating, lever-handle actuator.
6. Consumption: 1.6 gal./flush (6.0 L/flush).
7. Tailpiece Size: NPS 1-1/2 (DN 40) and standard length to top of bowl.
8. Bedpan Washer: Not required.

B. Flushometer, WC-3 & WC-4: Cast-brass body with corrosion-resistant internal components,non-hold-open feature, control stop with check valve, vacuum breaker, and copper or brass tubing, and polished chrome-plated finish on exposed parts.
1. Manufacturers:

a. Sloan Royal. BPW 1100-1.6.

2. Internal Design: Diaphragm operation.
3. Style: Exposed.
4. Inlet Size: NPS 1 (DN 25).
5. Trip Mechanism: Oscillating, lever-handle actuator.
6. Consumption: 1.6 gal./flush (6.0 L/flush).
7. Tailpiece Size: NPS 1-1/2 (DN 40) and standard length to top of bowl.
8. Bedpan Washer: Factory fabricated, attached to tailpiece, and with spray head

C. Flushometer, CSS-1: Cast-brass body with corrosion-resistant internal components, non-hold-open feature, control stop with check valve, vacuum breaker, and copper or brass tubing, and polished chrome-plated finish on exposed parts.
1. Manufacturers:

a. Sloan Royal. BPW 9000-1.6 W/V-500-AA Extension.

2. Internal Design: Diaphragm operation.
3. Style: Exposed.
4. Inlet Size: NPS 1 (DN 25).
5. Trip Mechanism: Push-button with stainless-steel access plate actuator.
6. Consumption: 1.6 gal./flush (6.0 L/flush).
7. Tailpiece Size: NPS 1-1/2 (DN 40)] with extension tail piece.
8. Bedpan Washer: Factory fabricated, attached to tailpiece, and with spray head

D. Flushometer, U-1 & U-2: Cast-brass body with corrosion-resistant internal components, non-hold-open feature, control stop with check valve, vacuum breaker, and copper or brass tubing, and polished chrome-plated finish on exposed parts.

1. Manufacturers:

a. Sloan Royal. 186-1.6

2. Internal Design: Diaphragm operation.

3. Style: Exposed.
4. Inlet Size: NPS 1 (DN 25).
5. Trip Mechanism: Push-button with stainless-steel access plate actuator.
6. Consumption: 1.6 gal./flush (6.0 L/flush).
7. Tailpiece Size: NPS 1-1/2 (DN 40)] and standard length to top of bowl.
8. Bedpan Washer: Factory fabricated, attached to tailpiece, and with spray head

2.6 TOILET SEATS

A. Toilet Seat, : Solid plastic.

1. Manufacturers:

a. Centoco, Beneke, Church or Bemis.

2. Configuration: Open front without cover.
3. Size: Elongated.
4. Class: Heavy-duty commercial.
5. Hinge Type: SC, self-sustaining, check.
6. Color: White.

2.7 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Guard, L-1, L-2, L-3, SK-4, SK-5 & SK-6: Manufactured, plastic covering for hot- and cold-water supplies and trap and drain piping and complying with ADA requirements.

1. Manufacturers:

a. Truebro.
b. McGuire.

2.8 FIXTURE SUPPORTS

A. Water-Closet Support, WC-1 through 4: Water-closet combination carrier designed for accessible & standard mounting height. Include single or double, vertical or horizontal, 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. Refer to section 3.2, B.4.

1. Manufacturers:

a. Jay R. Smith.

B. Urinal Support, U-1 & U-2: Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include steel uprights with feet.

1. Manufacturers:

a. Jay R. Smith. 0637

2. Accessible Fixture Support: Include rectangular steel uprights.

C. Lavatory Support, L-2 & SK-6: Type II, lavatory carrier with concealed arms and tie rod]. Include steel uprights with feet.

1. Manufacturers:

a. Jay R. Smith. 700-16-Z-M32.

2. Accessible Fixture Support: Include rectangular steel uprights. Concealed arms shall be 16-inches long for mounting fixture flush to wall.

2.9 HOT-WATER DISPENSERS

A. Hot-Water Dispenser, SK-3: Household type with instant on-off control; insulated, corrosion-resistant-metal storage tank that is open to atmosphere; electric, 115-V ac, heating element; chrome-plated faucet or spout; removable strainer; thermostat control for water temperature up to 190 deg F (88 deg C); and thermal-overload protection.

1. Available Manufacturers:
2. Manufacturers:

a. Elkay: LKH
b. In-Sinkerator: H-770

3. Minimum Tank Capacity: 0.5 gal. (1.9 L)
4. Minimum Input: 775 W.
5. Spout: Twist-knob spout assembly.

2.10 WATER CLOSETS

A. Water Closets, WC-1 & WC-2: Wall-hanging, back-outlet, vitreous-china fixture designed for flushometer valve operation. Refer to Architectural sections for fixture mounting heights.

B. Available Products:
1. Products:

a. Kohler: K-4330 "Kingston".

2. Style: Flushometer valve.

a. Bowl Type: Elongated with siphon-jet design.

1) Design Consumption: 1.6 gal./flush (6 L/flush).

b. Color: White.

C. Water Closets, WC-3 & WC-4: Wall-hanging, back-outlet, vitreous-china fixture designed for bedpan washing and flushometer valve operation. Refer to Architectural sections for fixture mounting heights.

1. Available Products:
2. Products:

a. Kohler: K-4330-L "Kingston".

3. Style: Flushometer valve.

a. Bowl Type: Elongated with siphon-jet design and bedpan lugs.
b. Design Consumption: [1.6 gal./flush (6 L/flush)].
c. Color: White.

2.11 URINALS

A. Urinals, U-1 & U-2: Accessible, wall-hanging, back-outlet, vitreous-china fixture designed for flushometer valve operation.

1. Available Products:
2. Products:

a. Kohler; K-4989-T "Freshman Lite".

3. Type: Siphon jet.
4. Strainer or Trapway: Open trapway with integral trap.
5. Design Consumption: 1 gal./flush (3.8 L/flush).
6. Color: White.
7. Supply Spud Size: NPS 3/4 (DN 20).
8. Outlet Size: NPS 2 (DN 50).

2.12 LAVATORIES

A. Lavatories, L-1: Accessible, vitreous-china fixture.

1. Available Products:
2. Products:

    a. Kohler; K-2196 "Pennington".

3. Type: Coutertop.
4. Size: 20 by 18 inches (508 by 457 mm) oval.
5. Faucet Hole Punching: Three, 8-inch centerset.
6. Faucet Hole Location: Top.
7. Color: White.
8. Faucet: Lavatory L-1.
9. Supplies: NPS 3/8 (DN 10) chrome-plated copper with stops.
10. Drain: Grid w/offset.
11. Drain Piping: NPS 1-1/4 by NPS 2 chrome-plated cast-brass trap, and brass waste to wall with wall escutcheon.
12. Protective Shielding Guard[s]: L-1.

B. Lavatories, L-2: Accessible, vitreous-china fixture.

1. Available Products:
2. Products:
    a. Kohler; K-2053 "Soho"

3. Type: Flat rim with ledge.
4. Rectangular Lavatory Size: 20 by 18 inches (508 by 457 mm).
5. Faucet Hole Punching: Three, 8-inch centerset.
6. Faucet Hole Location: Top.
7. Color: White.
8. Faucet: Lavatory L-2.
9. Supplies: NPS 3/8 (DN 10) chrome-plated copper with stops.
10. Drain: Grid w/offset.
11. Drain Piping: NPS 1-1/4 by NPS 2 chrome-plated cast-brass trap, and brass waste to wall with wall escutcheon.
12. Protective Shielding Guard[s]: L-2.

C. Lavatories, L-3: Corian fixture (OFCI).

1. Type: Flat rim with ledge.
2. Faucet Hole Punching: Three, 8-inch centerset.
3. Faucet Hole Location: Top.
4. Faucet: Lavatory L-3.
5. Supplies: NPS 3/8 (DN 10) chrome-plated copper with stops.
6. Drain: Grid w/offset
7. Drain Piping: NPS 1-1/4 by NPS 2 chrome-plated cast-brass trap, and brass waste to wall with wall escutcheon.
8. Protective Shielding Guard[s]: L-3.

2.13 INDIVIDUAL SHOWERS

A. Individual Showers, SH-1: Shower enclosure with slip-resistant bathing surface complying with ASTM F 462 and shower rod with curtain.

1. Available Products:
2. Products:
   a. Acryline USA Inc; ASA4040BF.

3. Size: 36 by 36 inches I.D.
4. Material: Acrylic, one-piece surround.
5. Color: White.
6. Drain Location: Center.
7. Accessibility Options: Include grab bar and padded fold-up seat.
8. Faucet: Shower SH-1.
9. Drain: Grid, NPS 2 (DN 50).
10. Light: Lightolier Model 1102DH2, HPF-277V frame-in kit w/1177SH/1102D Series reflector trim.

B. **Alternate No. 7 Showers, SH-1:** Shower enclosure with slip-resistant bathing surface complying with ASTM F 462 and shower rod with curtain.

1. Available Products:
2. Products:

   a. Tile unit (OFCI).

3. Faucet: Shower SH-1.
4. Drain: Grid, NPS 2 (DN 50).

C. Individual Showers, SH-2: Shower enclosure with slip-resistant bathing surface complying with ASTM F 462 and shower rod with curtain.

1. Available Products:
2. Products:
   a. Acryline USA Inc; A-3636-ADA-FUS-2".

3. Size: 36 by 36 inches I.D.
4. Material: Acrylic, one-piece surround.
5. Color: White.
6. Drain Location: Center.
7. Accessibility Options: Include grab bar and padded fold-up seat.
8. Faucet: Shower SH-2.
9. Drain: Grid, NPS 2 (DN 50).
10. Light: Lightolier Model 1102DH2, HPF-277V frame-in kit w/1177SH/1102D Series reflector trim.

D. Individual Showers, SH-3: Shower enclosure with slip-resistant bathing surface complying with ASTM F 462 and shower rod with curtain.

1. Available Products:
2. Products:
   a. Acryline USA Inc; A-4836-BF-FUS-2".

3. Size: 47 by 36 inches I.D.
4. Material: Acrylic, one-piece surround.
5. Color: White.
6. Drain Location: Center.
7. Accessibility Options: Include grab bar and padded fold-up seat.
8. Faucet: Shower SH-1.
9. Drain: Grid, NPS 2 (DN 50).
10. Light: Lightolier Model 1102DH2, HPF-277V frame-in kit w/1177SH/1102D Series reflector trim.

2.14 HYDROMAESSAGE TUBS

A. Hydromessage Tubs, TB-1: Hydromassage bathtub with jet nozzles and water circulation.

1. Available Products:
2. Products:

   a. Acryline USA Inc.; "Bis-R" Aquamassuer.

3. Material: Acrylic plastic, with slip-resistant bathing surface.
4. Size: 66 by 42 inches (1525 by 1065 mm) with front apron.
5. Color: White.
6. Drain Location: Left or Right end as required.
7. Multi-Function Control. On/off, 20 min. timer, indicator light, variable speed, wave & pulse mode, auto-dry cycle, 24hr purge, and on/off heat.
8. Injectors: 18 air injectors with check valves.
9. Injector Location: 9-bottom jets (avoid seat area) and 9-back jets.
10. Faucet: Refer to 2.3 Shower Faucets SH-1.
11. Supplies: NPS 1/2 (DN 15) copper tubing with ball valves.
12. Drain: NPS 1-1/2 (DN 40); chrome-plated exposed parts; brass pop-up waste and overflow.
13. Drain Piping: NPS 2 cast-brass trap and waste.
14. Circulating System: Electric, 120-V ac, 15amp pump and plastic piping. Provide hard wired circuit protected by GFI.

2.15 SINKS

A. Sinks, SK-1 & SK-3: Counter-mounting, 18-gage stainless-steel fixture.

1. Available Products:
2. Products:
   a. Elkay Manufacturing Co.; LR-1720.
   b. Kindred Industries Limited.: LBS-6408P-1

3. Overall Size: 17 by 20 inches (432 by 508 mm)].
4. Number of Compartments: One.
5. Sink Faucet: Refer to Section 2.4.
6. Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops.
7. Drain Piping: NPS 2 chrome-plated cast-brass trap, 0.045-inch- (1.1-mm-) thick tubular brass waste to wall, continuous waste, and wall escutcheon[s].
8. Hot-Water Dispenser: SK-3 only.

B. Sinks, SK-2: Counter-mounting, 18-gage stainless-steel fixture.

1. Available Products:
2. Products:
   a. Elkay Manufacturing Co.; LR-2222.
   b. Kindred Industries Limited.: LBS-6808P-1

3. Overall Size: 22 by 22 inches (559 by 559 mm)].
4. Number of Compartments: One.
5. Sink Faucet: Refer to Section 2.4.
6. Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops.
7. Drain Piping: NPS 2 chrome-plated cast-brass trap, 0.045-inch- (1.1-mm-) thick tubular brass waste to wall, continuous waste, and wall escutcheon[s].

C. Sinks, SK-4: Wall-hung, vitreous china fixture.

1. Available Products:
2. Products:
   a. Kohler; K-2170-8 "Lady Vanity".

3. Overall Size: 28 by 19 inches.
4. Number of Compartments: One.
5. Sink Faucet: Refer to Section 2.4.
6. Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops.
7. Drain Piping: NPS 2 chrome-plated cast-brass trap, 0.045-inch- (1.1-mm-) thick tubular brass waste to wall, continuous waste, and wall escutcheon[s] with off-set grid drain and protective wrap.

D. Sinks, SK-5: Integral Corian (OFCI).

1. Sink Faucet: SK-5.
2. Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops.

3. Drain Piping: NPS 2 chrome-plated cast-brass trap, 0.045-inch- (1.1-mm-) thick tubular brass waste to wall, continuous waste, and wall escutcheon[s] with off-set grid strainer and protective wrap.

E. Sinks, SK-6 & SK-8: Wall-hung, vitreous china fixture.

1. Available Products:
2. Products:
   a. Kohler; K-2006 "Kingston".

3. Overall Size: 21 by 18 inches.
4. Number of Compartments: One.
5. Sink Faucet: Refer to Section 2.4.
6. Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops.
7. Drain Piping: NPS 2 chrome-plated cast-brass trap, 0.045-inch- (1.1-mm-) thick tubular brass waste to wall, continuous waste, and wall escutcheon[s] with off-set grid drain and protective wrap.

F. Sinks, SK-7: Counter-mounting, 18-gage stainless-steel fixture.

1. Available Products:
2. Products:
   a. Elkay Manufacturing Co.; 1720 "Sacristy".

3. Overall Size: 17 by 20 inches .
4. Number of Compartments: One.
5. Cover: 304 Stainless steel cover with piano hinge, cross, finger lift, and cylinder lock.
6. Sink Faucet: Refer to Section 2.4.
7. Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops.
8. Drain Piping: NPS 2 chrome-plated cast-brass (no trap or vent) and escutcheon[s]. Run drain separate from plumbing system to dry-well provided by Div. 2.and escutcheon[s].

2.16 SERVICE BASINS

A. Service Basins, MSB-1: Flush-to-wall, floor-mounting molded stone basin with rim guard.

1. Available Products:
2. Products:

   a. Fiat Products; MSB-3624.

3. Shape: Rectangular.
4. Size: 36 by 24 inches (915 by 610 mm).

5. Height: 10 inches (255 mm).
6. Tiling Flange: On two sides.
7. Rim Guard: On front top surfaces.
8. Color: Not applicable.
9. Faucet: Refer to Section 2.4.
10. Drain: Grid with NPS 3 (DN 80) outlet.

2.17 CLINICAL SINKS

A. Clinical Sinks, CSS-1: Wall-mounting, back-outlet, vitreous-china, flushing-rim service sink.

1. Available Products:
2. Products:

    a. Kohler; K-12867 "Camerton".

3. Size: Approximately 25 by 20 inches (635 by 510 mm).
4. Color: White.
5. Rim Guard: Stainless steel on front and also on sides if flat rim.

2.18 SURGEON'S SCRUB-UP SINKS

A. Surgeon's Scrub-up Sinks, SS-1: Wall-mounting, stainless-steel fixture.

1. Available Products:
2. Products:

    a. Acorn Engineering; 4101-MC-SA-PDM-SO Scrub-Ware.

3. Size: Approximately 32 by 27 inches with back with one faucet hole.
4. Faucet: Chrome-plated-brass, sensor gooseneck type matching fixture with electric eye control for mixing hot- and cold-water supplies.
5. Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops.
6. Drain: Grid, NPS 1-1/2 (DN 40).
7. Drain Piping: NPS 1-1/2 (DN 40) chrome-plated cast-brass trap, 0.045-inch- (1.1-mm-) thick tubular-brass waste to wall, and wall flange.
8. Fixture Support: Sink wall support MC.

B. Surgeon's Scrub-up Sinks, SS-2: Wall-mounting, stainless-steel fixture.

1. Available Products:
2. Products:

    a. Acorn Engineering; 4102-MC-SA-PDM-SO-DTD Scrub-Ware.

3. Size: Approximately 64 by 27 inches with back with two faucet hole.
4. Faucet: Chrome-plated-brass, sensor gooseneck type matching fixture with electric eye control for mixing hot- and cold-water supplies.
5. Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops.
6. Drain: Grid, NPS 1-1/2 (DN 40).
7. Drain Piping: NPS 1-1/2 (DN 40) chrome-plated cast-brass trap, 0.045-inch- (1.1-mm-) thick tubular-brass waste to wall, and wall flange.
8. Fixture Support: Sink wall support MC.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water soil and for waste piping systems and supports to verify actual locations and sizes of piping connections and that locations and types of supports match those indicated, before plumbing fixture installation. Use manufacturer's roughing-in data if roughing-in data are not indicated.

B. Examine walls, floors, and cabinets for suitable conditions where fixtures are to be installed.

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

3.2 FIXTURE INSTALLATION

A. Assemble fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. For wall-hanging fixtures, install off-floor supports affixed to building substrate.

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.
4. All wall hung water closet carriers shall be installed with an accessible cleanout located above the flood level of the fixture. A minimum 2-inch tee shall be installed in the vent piping from the carrier with ¼ bend to wall and cleanout on either side of fixture. Tee and bend shall be supported. A stainless steel access plate shall cover cleanout. Refer to detail No. 22, dwg. P002.

C. Install back-outlet, wall-hanging fixtures onto waste fitting seals and attach to supports.

D. Install wall-hanging fixtures with tubular waste piping attached to supports.

E. Install counter-mounting fixtures in and attached to casework.

F. Install fixtures level and plumb according to manufacturers' written instructions and roughing-in drawings.

G. 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 valve if stops are not specified with fixture. Refer to Division 15 Section "Valves" for general-duty valves.

H. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

I. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

J. 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.

K. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.

L. Install toilet seats on water closets.

M. 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.

N. Install water-supply, flow-control fittings with specified flow rates in fixture supplies at stop valves.

O. 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.

P. Install shower, flow-control fittings with specified maximum flow rates in shower arms.

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 disposer in outlet of sinks indicated to have disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.

S. Install hot-water dispensers in back top surface of sink or in counter with spout over sink.

T. 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. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for escutcheons.

U. Set [shower receptors,] [and] [service basins] in leveling bed of cement grout. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for grout.

V. Seal joints between fixtures and walls, floors, and counters using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Refer to Division 7 Section "Joint Sealants" for sealant and installation requirements.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect water supplies from water distribution piping to fixtures.

C. Connect drain piping from fixtures to drainage piping.

D. Supply and Waste Connections to Plumbing Fixtures: Connect fixtures with water supplies, stops, risers, traps, and waste piping. Use size fittings required to match fixtures. Connect to plumbing piping.

E. Supply and Waste Connections to Fixtures and Equipment Specified in Other Sections: Connect fixtures and equipment with water supplies, stops, risers, traps, and waste piping specified. Use size fittings required to match fixtures and equipment. Connect to plumbing piping.

F. Ground equipment.

1. 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.

3.4 FIELD QUALITY CONTROL

A. Verify that installed fixtures are categories and types specified for locations where installed.

B. Check that fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed 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. Operate and adjust [hot-water dispensers,] [and] [controls]. Replace damaged and malfunctioning units [and controls].

C. Adjust water pressure at [faucets,] [shower valves,] [and] [flushometer valves] to produce proper flow and stream.

D. Replace washers and seals of leaking and dripping faucets and stops.

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.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 15410

SECTION 15415 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

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. Fitting: Device that controls flow of water into or out of fixture.

C. Fixture: Water cooler, unless one is specifically indicated.

D. Water Cooler: Electrically powered fixture for generating and delivering cooled drinking water.

1.4 SUBMITTALS

A. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each type of fixture indicated.

B. Shop Drawings: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

D. Maintenance Data: For fixtures to include in maintenance manuals specified in Division 1.

E. Acceptable Substitute Manufacturers: All bidders desiring to furnish equipment other than that specified must submit a complete verification specification for the substituted equipment along with literature, wiring diagrams, piping diagrams, and a list of similar sized installations where proposed equipment is installed. The complete submittal must be presented to the Architect at least (7) full working days prior to the bid opening for approval. Substitutions will not be permitted after the contract has been awarded. Refer to Specification Section 01300, SUBMITTALS AND SUBSTITUTIONS.

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";] about fixtures for people with disabilities.

C. Regulatory Requirements: Comply with requirements in the U.S. Architectural & Transportation Barriers Compliance Board's "Uniform Federal Accessibility Standards (UFAS), 1985-494-187" about fixtures for people with disabilities.

D. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

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.

1.6 COORDINATION

A. Coordinate roughing-in and final fixture locations, and verify that fixtures can be installed to comply with original design and referenced standards.

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. Filter Cartridges: Equal to 10 percent of amount installed for each type and size indicated, but not less than 6 of each.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. For fixture descriptions in other Part 2 articles where the subparagraph titles ["Available Manufacturers,"] [and] ["Manufacturers"] introduce a list of manufacturers and their products or manufacturers only, the following requirements apply for product selection:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the products specified in other Part 2 articles.
2. Products: Subject to compliance with requirements, provide one of the products specified in other Part 2 articles.
3. 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 in other Part 2 articles.
4. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified in other Part 2 articles.

2.2 PRESSURE WATER COOLERS

A. Water Coolers, EWC-1: ARI 1010, Type PB, pressure with bubbler, Style RE, recessed fixture, bi-level.

1. Available Products:
2. Products:

    a. Halsey Taylor; OVL-II-SER-Q.

3. Cabinet: All stainless steel.
4. Bubbler: Two, with automatic stream regulator, located on each deck.
5. Control: Push bar.
6. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve [and filter].
7. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.1M.
8. Cooling System: Electric, with [precooler,] hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.

    a. Capacity: [8 gph (0.0084 L/s)] of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
    b. Electrical Characteristics: 4.7 Amp; 120-V ac; single phase; 60 Hz.

9. Ventilation Grille: Stainless steel, located below fountain.
10. Support: Mounting frame for attaching to substrate.

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 mounting frames for recessed water coolers, unless otherwise indicated.

B. 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-hanging 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.

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. Refer to Division 15 Section "Valves" for general-duty valves.

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. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for escutcheons.

G. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Refer to Division 7 Section "Joint Sealants" for sealant and installation requirements.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect water supplies from water distribution piping to fixtures.

C. Connect drain piping from fixtures to drainage piping.

D. Ground equipment.

1. 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.

3.5 FIELD QUALITY CONTROL

A. Water-Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.

B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

C. 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 15415

SECTION 15430 - PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following plumbing specialties:

1. Backflow preventers.
2. Water regulators.
3. Balancing valves.
4. Water filters.
5. Thermostatic water mixing valves.
6. Strainers.
7. Key-operation hydrants.
8. Wheel-handle wall hydrants.
9. Nondraining nonfreeze post hydrants.
10. Trap seal primer valves.
11. Drain valves.
12. Backwater valves.
13. Miscellaneous piping specialties.
14. Sleeve penetration systems.
15. Flashing materials.
16. Cleanouts.
17. Floor drains.
18. Trench drains.
19. Roof drains.

B. Related Sections include the following:

1. Division 15 Section "Meters and Gages" for water meters, thermometers, and pressure gages.

1.3 DEFINITIONS

A. The following are industry abbreviations for plastic piping materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.

2. PE: Polyethylene plastic.
3. PUR: Polyurethane plastic.
4. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing piping systems with following minimum working-pressure ratings, unless otherwise indicated:

1. Domestic Water Piping: 125 psig (860 kPa).
2. Sanitary Waste and Vent Piping: 10-foot head of water (30 kPa).
3. Storm Drainage Piping: 10-foot head of water (30 kPa).
4. Force-Main Piping: 100 psig (690 kPa).

1.5 SUBMITTALS

A. Product Data: Include rated capacities and shipping, installed, and operating weights. Indicate materials, finishes, dimensions, required clearances, and methods of assembly of components; and piping and wiring connections for the following:

1. Backflow preventers and water regulators.
2. Balancing valves, water filters, and strainers.
3. Thermostatic water mixing valves and water tempering valves.
4. Water hammer arresters, air vents, and trap seal primer valves and systems.
5. Drain valves, hose bibbs, hydrants, and hose stations.
6. Outlet boxes and washer-supply outlets.
7. Backwater valves, cleanouts, floor drains, open receptors, trench drains, and roof drains.
8. Air-admittance valves, vent caps, vent terminals, and roof flashing assemblies.
9. Sleeve penetration systems.

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

C. Field test reports.

D. Maintenance Data: For plumbing specialties to include in maintenance manuals. Include the following:

1. Backflow preventers and water regulators.
2. Water filters.
3. Thermostatic water mixing valves and water tempering valves.
4. Trap seal primer valves and systems.
5. Hose stations and hydrants.

E. Acceptable Substitute Manufacturers: All bidders desiring to furnish equipment other than that specified must submit a complete verification specification for the substituted equipment along with literature, wiring diagrams, piping diagrams, and a list of similar sized installations where proposed equipment is installed. The complete submittal must be presented to the Architect at least (7) full working days prior to the bid opening for approval. Substitutions will not be permitted after the contract has been awarded. Refer to Specification Section 01300, SUBMITTALS AND SUBSTITUTIONS.

1.6 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of plumbing specialties and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Plumbing specialties shall bear label, stamp, or other markings of specified testing agency.

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: Comply with ASME B31.9, "Building Services Piping," for piping materials and installation.

E. NSF Compliance:

1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components. Include marking "NSF-pw" on plastic potable-water piping and "NSF-dwv" on plastic drain, waste, and vent piping.
2. Comply with NSF 61, "Drinking Water System Components--Health Effects, Sections 1 through 9," for potable domestic water plumbing specialties.

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 Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the products specified.
2. Products: Subject to compliance with requirements, provide one of the products specified.

3. 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.
4. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 BACKFLOW PREVENTERS

A. Available Manufacturers:

B. Manufacturers:

1. Watts Industries, Inc.; Water Products Div.

C. General: ASSE standard, backflow preventers.

1. NPS 2 (DN 50) and Smaller: Bronze body with threaded ends.
2. NPS 2-1/2 (DN 65) and Larger: Bronze, cast-iron, steel, or stainless-steel body with flanged ends.

a. Interior Lining: AWWA C550 or FDA-approved, epoxy coating for backflow preventers having cast-iron or steel body.

3. Interior Components: Corrosion-resistant materials.
4. Exterior Finish: Polished chrome plate if used in chrome-plated piping system.
5. Strainer: On inlet, if indicated.

D. Pipe-Applied, Atmospheric-Type Vacuum Breakers: ASSE 1001, with floating disc and atmospheric vent.

E. Hose-Connection Vacuum Breakers: Woodford Series 37, ASSE 1011, nickel plated, with nonremovable and manual drain features, and ASME B1.20.7, garden-hose threads on outlet. Units attached to rough-bronze-finish hose connections may be rough bronze.

F. Reduced-Pressure-Principle Backflow Preventers (HVAC Make-up/Irrigation): Watts Series 909QTS, ASSE 1013, suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet; test cocks; and pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between two positive-seating check valves.

1. Pressure Loss: 12 psig (83 kPa) maximum, through middle 1/3 of flow range.

2.3 BALANCING VALVES

A. Memory-Stop Balancing Valves, NPS 2 (DN 50) and Smaller: MSS SP-110, ball valve, rated for 400-psig (2760-kPa) minimum CWP. Include two-piece, copper-alloy body

with standard or full-port, chrome-plated brass ball, replaceable seats and seals, threaded or solder-joint ends, and vinyl-covered steel handle with memory-stop device.

1. Available Manufacturers:
2. Manufacturers:

    a. Bell & Gossett: Circuit Setter.
    b. Taco Products: Accu-Flo.

2.4 THERMOSTATIC WATER MIXING VALVES

A. Available Manufacturers:

B. Manufacturers:

1. Lawler Manufacturing Company, Inc.
2. Leonard Valve Company.
3. Symmons Industries Inc.

C. General: ASSE 1017, manually adjustable, thermostatic water mixing valve with bronze body. Include check stop and union on hot- and cold-water-supply inlets, adjustable temperature setting, and thermometer.

1. Type: Bimetal thermostat, operation and pressure rating 125 psig (860 kPa) minimum.
2. Type: Liquid-filled motor, operation and pressure rating 100 psig (690 kPa) minimum.

2.5 STRAINERS

A. Strainers: Y-pattern, unless otherwise indicated, and full size of connecting piping. Include ASTM A 666, Type 304, stainless-steel screens with 3/64-inch (1.2-mm) round perforations, unless otherwise indicated.

1. Pressure Rating: 125-psig (860-kPa) minimum steam working pressure, unless otherwise indicated.
2. NPS 2 (DN 50) and Smaller: Bronze body, with female threaded ends.
3. NPS 2-1/2 (DN 65) and Larger: Cast-iron body, with interior AWWA C550 or FDA-approved, epoxy coating and flanged ends.
4. Y-Pattern Strainers: Screwed screen retainer with centered blowdown.

    a. Drain: Factory- or field-installed, hose-end drain valve.

2.6 KEY-OPERATION HYDRANTS

A. Available Manufacturers:

B. Manufacturers:

1. Woodford Manufacturing Co.

C. General: ASME A112.21.3M, key-operation hydrant with pressure rating of 125 psig (860 kPa).

1. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25) threaded or solder joint.
2. Outlet: ASME B1.20.7, garden-hose threads.
3. Operating Keys: One with each key-operation hydrant.

D. Nonfreeze Concealed-Outlet Wall Hydrants: Woodford Series B65, ASSE 1019, self-drainable with flush-mounting box with cover, integral nonremovable hose-connection vacuum breaker, casing and operating rod to match wall thickness, concealed outlet, and wall clamp.

1. Classification: Type A, for automatic draining with hose removed or Type B, for automatic draining with hose removed or with hose attached and nozzle closed.
2. Box and Cover Finish: Polished chrome plate.

E. Hot and Cold, Nonfreeze Concealed-Outlet Wall Hydrants: Woodford Series HCB67, With deep flush-mounting box with cover; hot- and cold-water casings and operating rods to match wall thickness; concealed outlet; wall clamps; and factory- or field-installed, nonremovable and manual drain-type, hose-connection vacuum breaker complying with ASSE 1011.

1. Box and Cover Finish: Polished chrome plate. Locate at roof level, Stair No. 2.

2.7 TRAP SEAL PRIMER VALVES

A. Supply-Type Trap Seal Primer Valves: ASSE 1018, water-supply-fed type, with the following characteristics:

1. Available Manufacturers:
2. Manufacturers:

a. MIFAB Manufacturing, Inc.
b. Precision Plumbing Products, Inc.

3. 125-psig (860-kPa) minimum working pressure.
4. Bronze body with atmospheric-vented drain chamber.
5. Inlet and Outlet Connections: NPS 1/2 (DN 15) solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 (DN 15) solder joint.
7. Finish: Chrome plated.

8. Distribution Unit: TP-2 requires 2-gravity lines; TP-3 requires 3-gravity lines; TP-4 requires 4-gravity lines.

2.8 DRAIN VALVES

A. Hose-End Drain Valves: MSS SP-110, NPS 3/4 (DN 20) ball valve, rated for 400-psig (2760-kPa) minimum CWP. Include two-piece, copper-alloy body with standard port, chrome-plated brass ball, replaceable seats and seals, blowout-proof stem, and vinyl-covered steel handle.

1. Inlet: Threaded or solder joint.
2. Outlet: Short-threaded nipple with ASME B1.20.7, garden-hose threads and cap.

B. Hose-End Drain Valve: MSS SP-80, gate valve, Class 125, ASTM B 62 bronze body, with NPS 3/4 (DN 20) threaded or solder-joint inlet and ASME B1.20.7, garden-hose threads on outlet and cap. Hose bibbs are prohibited for this application.

C. Stop-and-Waste Drain Valves: MSS SP-110, ball valve, rated for 200-psig (1380-kPa) minimum CWP or MSS SP-80, Class 125, gate valve; ASTM B 62 bronze body, with NPS 1/8 (DN 6) side drain outlet and cap.

2.9 BACKWATER VALVES

A. Available Manufacturers:

B. Manufacturers:

1. Josam Co.
2. Smith, Jay R. Mfg. Co.
3. Watts Industries, Inc.; Drainage Products Div.
4. Zurn Industries, Inc.; Specification Drainage Operation.

C. Horizontal Backwater Valves: Jay R. Smith Model 7150 with extension, ASME A112.14.1, cast-iron body, with removable bronze swing-check valve and threaded or bolted cover.

1. Closed-Position Check Valve: Factory assembled or field modified to hang closed unless subject to backflow condition.
2. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor, instead of cover.

D. Vertical Backwater Valves: ASME A112.14.1, cast-iron body, with removable bronze swing-check valve and threaded or bolted cover.

1. Drain Outlet Valve: Jay R. Smith Model 7080, Factory assembled with ball float closing subject to backflow condition. Install at basement foundation in Mech. B026 to receive sprinkler system drain.

2.10 MISCELLANEOUS PIPING SPECIALTIES

A. Water Hammer Arresters: ASSE 1010 or PDI-WH 201, metal-bellows type with pressurized metal cushioning chamber. Sizes indicated are based on ASSE 1010 or PDI-WH 201, Sizes A through F.

1. Available Manufacturers:
2. Manufacturers:

    a. Josam Co.
    b. Smith, Jay R. Mfg. Co.
    c. Tyler Pipe; Wade Div.
    d. Zurn Industries, Inc.; Specification Drainage Operation.

B. Water Hammer Arresters: ASSE 1010 or PDI-WH 201, piston type with pressurized metal-tube cushioning chamber. Sizes indicated are based on ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

1. Available Manufacturers:
2. Manufacturers:

    a. Amtrol, Inc.
    b. Josam Co.
    c. Precision Plumbing Products, Inc.
    d. Sioux Chief Manufacturing Co., Inc.
    e. Watts Industries, Inc.; Water Products Div.
    f. Zurn Industries, Inc.; Wilkins Div.

C. Hose Bibbs: Woodford Series 26, Bronze body with replaceable seat disc complying with ASME A112.18.1M for compression-type faucets. Include NPS 1/2 solder-joint inlet, of design suitable for pressure of at least 125 psig (860 kPa); integral [or field-installed,] nonremovable, drainable hose-connection vacuum breaker; and garden-hose threads complying with ASME B1.20.7 on outlet.

1. Finish for Equipment Rooms: Chrome plated.
2. Operation for Equipment Rooms: Wheel handle.
3. Operation for Finished Rooms: Operating key.
4. Include operating key with each operating-key hose bibb.
5. Include integral wall flange with each chrome-plated hose bibb.

D. Air Vents: Float type for automatic air venting.

1. Bolted Construction: Bronze body with replaceable, corrosion-resistant metal float and stainless-steel mechanism and seat; threaded [NPS 3/8 (DN 10)] [NPS 1/2 (DN 15)] minimum inlet; 125-psig (860-kPa) minimum pressure rating at 140 deg F (60 deg C); and threaded vent outlet.
2. Welded Construction: Stainless-steel body with corrosion-resistant metal float, stainless-steel mechanism and seat, threaded NPS 3/8 (DN 10) minimum inlet, 150-psig (1035-kPa) minimum pressure rating, and threaded vent outlet.

E. Open Drains: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting, joined with ASTM C 564, rubber gaskets.

F. Deep-Seal Traps: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap seal primer valve connection.

1. NPS 2 (DN 50): 4-inch- (100-mm-) minimum water seal.
2. NPS 2-1/2 (DN 65) and Larger: 5-inch- (125-mm-) minimum water seal.

G. Floor-Drain Inlet Fittings: Cast iron, with threaded inlet and threaded or spigot outlet, and trap seal primer valve connection.

H. Fixed Air-Gap Fittings: Manufactured cast-iron or bronze drainage fitting with semiopen top with threads or device to secure drainage inlet piping in top and bottom spigot or threaded outlet larger than top inlet. Include design complying with ASME A112.1.2 that will provide fixed air gap between installed inlet and outlet piping.

I. Stack Flashing Fittings: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.

J. Vent Terminals: Commercially manufactured, shop- or field-fabricated, frost-proof assembly constructed of galvanized steel, copper, or lead-coated copper. Size to provide 1-inch (25-mm) enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.

K. Expansion Joints: ASME A112.21.2M, assembly with cast-iron body with bronze sleeve, packing gland, and packing; of size and end types corresponding to connected piping.

2.11 SLEEVE PENETRATION SYSTEMS

A. Available Manufacturers:

B. Manufacturers:

1. ProSet Systems, Inc.
2. Linkseal.

C. Description: UL 1479, through-penetration firestop assembly consisting of sleeve and stack fitting with firestopping plug.

1. Sleeve: Cast-iron, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
2. Stack Fitting: ASTM A 48 (ASTM A 48M), gray-iron, hubless-pattern, wye-branch stack fitting with neoprene O-ring at base and gray-iron plug in thermal-release harness in branch.

a. Special Coating: Include corrosion-resistant interior coating on fittings for plastic chemical waste and vent stacks.

2.12 CLEANOUTS

A. Cleanouts: Comply with ASME A112.36.2M.

1. Application: Floor cleanout, Wall cleanout, and installation in exposed piping.
2. Available Products:
3. Products:
   a. Smith, Jay R. Mfg. Co.

4. Body or Ferrule Material: Cast iron.
5. Clamping Device: Required.
6. Outlet Connection: Threaded, Inside calk, Spigot.
7. Closure: Brass plug with straight threads and gasket.
8. Adjustable Housing Material: Cast iron with threads.
9. Frame and Cover Material and Finish: Polished bronze.
10. Frame and Cover Shape: Round.
11. Top Loading Classification: Medium Duty.

B. Cleanouts: Comply with ASME A112.36.2M.

1. Application: Wall cleanout.
2. Available Products:
3. Products:
   a. Smith, Jay R. Mfg. Co.; 4472-U-02-TP

4. Body or Ferrule Material: Cast bronze.
5. Outlet Connection: Taper Thread plug.
6. Closure: Brass plug with straight threads and gasket.
7. Frame and Cover Material and Finish: Stainless steel.
8. Cover Shape: Round.

2.13 FLOOR DRAINS

A. Floor Drains, 2"-FD: Comply with ASME A112.21.1M and ASME A112.3.1.

1. Application: Patient Toilet Room Floor drain (inside shower).
2. Available Products:
3. Products:

    a. Smith, Jay R. Mfg. Co.; 2005-02-U.

4. Body Material: Duco Cast iron.
5. Seepage Flange: Required, Secondary flashing flange.
6. Clamping Device: Required.
7. Outlet: Bottom.
8. Exposed Surfaces and Interior Lining: Acid-resistant.
9. Sediment Bucket: Required.
10. Top or Strainer Material: Nickel bronze.
11. Top of Body and Strainer Finish: Nickel bronze.
12. Top Shape: Round.
13. Dimensions of Top or Strainer: 5-inch.
14. Top Loading Classification: Medium Duty.
15. Inlet Fitting: Duco-cast iron, with threaded inlet and No-Hub outlet, and trap seal primer valve connection.
16. Trap Material: Copper.
17. Trap Pattern: Standard P-trap.
18. Trap Features: Cleanout and trap seal primer valve drain connection.

B. (**Alternate No. 7**) Floor Drains, 2"-FD: Comply with ASME A112.21.1M and ASME A112.3.1.

1. Application: Patient Toilet Room Floor drain (Tile shower unit by G.C.).
2. Available Products:
3. Products:

    a. Smith, Jay R. Mfg. Co.; DX2010-A-B-02-U.

4. Body Material: Duco Cast iron.
5. Seepage Flange: Required, Secondary flashing flange.
6. Clamping Device: Required.
7. Outlet: Bottom.
8. Exposed Surfaces and Interior Lining: Acid-resistant.
9. Sediment Bucket: Required.
10. Top or Strainer Material: Nickel bronze.
11. Top of Body and Strainer Finish: Nickel bronze.
12. Top Shape: Round.
13. Dimensions of Top or Strainer: 5-inch.
14. Top Loading Classification: Medium Duty.
15. Inlet Fitting: Duco-cast iron, with threaded inlet and No-Hub outlet, and trap seal primer valve connection.

16. Trap Material: Copper.
17. Trap Pattern: Standard P-trap.
18. Trap Features: Cleanout and trap seal primer valve drain connection.

C. Floor Drains, 3"-FD: Comply with ASME A112.21.1M and ASME A112.3.1.

1. Application: Public Toilet Room Floor drain (outside shower).
2. Available Products:
3. Products:

    a. Smith, Jay R. Mfg. Co.; 2005-03-U.

4. Body Material: Duco-coated Cast iron.
5. Seepage Flange: Required, Secondary flashing flange.
6. Clamping Device: Required.
7. Outlet: Bottom.
8. Exposed Surfaces and Interior Lining: Acid-resistant.
9. Sediment Bucket: Not Required.
10. Top or Strainer Material: Nickel bronze.
11. Top of Body and Strainer Finish: Nickel bronze.
12. Top Shape: Round.
13. Dimensions of Top or Strainer: 5-inch.
14. Top Loading Classification: Light Duty.
15. Inlet Fitting: Duco-cast iron, with threaded inlet and No-Hub outlet, and trap seal primer valve connection.
16. Trap Material: Copper.
17. Trap Pattern: Standard P-trap.
18. Trap Features: Cleanout and trap seal primer valve drain connection.

D. Floor Drains, 4"-FD: Comply with ASME A112.21.1M and ASME A112.3.1.

1. Application: Mechanical Room Floor drain.
2. Available Products:
3. Products:

    a. Smith, Jay R. Mfg. Co.; 2280-04-B-U.

4. Body Material: Duco Cast iron.
5. Seepage Flange: Required, Secondary flashing flange.
6. Clamping Device: Required.
7. Outlet: Bottom.
8. Exposed Surfaces and Interior Lining: Acid-resistant.
9. Sediment Bucket: Required.
10. Top or Strainer Material: Nickel bronze.
11. Top of Body and Strainer Finish: Nickel bronze.
12. Top Shape: Square.

13. Dimensions of Top or Strainer: 7.5-inches.
14. Top Loading Classification: Medium Duty.
15. Inlet Fitting: Duco-cast iron, with threaded inlet and No-hub outlet, and trap seal primer valve connection.
16. Trap Material: Cast iron.
17. Trap Pattern: Deep-seal P-trap.
18. Trap Features: Cleanout and trap seal primer valve drain connection.

2.14 AREA DRAINS

A. Area Drains, 3"-AD: Comply with ASME A112.21.1M and ASME A112.3.1.

1. Application: Penthouse Mechanical Room.
2. Available Products:
3. Products:

    a. Smith, Jay R. Mfg. Co.; 3001-15-NB-FBS-U-Y.

4. Body Material: Duco Cast iron.
5. Seepage Flange: Required, Secondary flashing flange.
6. Clamping Device: Required.
7. Outlet: Bottom.
8. Exposed Surfaces and Interior Lining: Acid-resistant.
9. Sediment Bucket: Required.
10. Top or Strainer Material: Nickel bronze.
11. Top of Body and Strainer Finish: Nickel bronze.
12. Top Shape: Square.
13. Dimensions of Top or Strainer: 12-inch.
14. Top Loading Classification: Medium Duty.
15. Inlet Fitting: Duco-cast iron, with threaded inlet and No-Hub outlet.

B. Area Drains, 4"-AD: Comply with ASME A112.21.1M and ASME A112.3.1.

1. Application: Sub-Basement Areaway/Basement future ED lobby.
2. Available Products:
3. Products:

    a. Smith, Jay R. Mfg. Co.; 3001-NB-FBS-U-Y.

4. Body Material: Duco Cast iron.
5. Seepage Flange: Required, Secondary flashing flange.
6. Clamping Device: Required.
7. Outlet: Bottom.
8. Exposed Surfaces and Interior Lining: Acid-resistant.
9. Sediment Bucket: Required.
10. Top or Strainer Material: Nickel bronze.

11. Top of Body and Strainer Finish: Nickel bronze.
12. Top Shape: Square.
13. Dimensions of Top or Strainer: 12-inch.
14. Top Loading Classification: Medium Duty.
15. Inlet Fitting: Duco-cast iron, with threaded inlet and No-Hub outlet.

C. Area Drains, 4"-AD: Comply with ASME A112.21.1M and ASME A112.3.1.

1. Application: Courtyard.
2. Available Products:
3. Products:

    a. Smith, Jay R. Mfg. Co.; 1419-C

4. Body Material: Duco Cast iron.
5. Seepage Flange: Required, Secondary flashing flange.
6. Clamping Device: Required.
7. Outlet: Bottom.
8. Exposed Surfaces and Interior Lining: Acid-resistant.
9. Sediment Bucket: Required.
10. Top or Strainer Material: Nickel bronze.
11. Top of Body and Strainer Finish: Nickel bronze.
12. Top Shape: Square.
13. Dimensions of Top or Strainer: 12-inch.
14. Extension: Perforated stainless steel.
15. Top Loading Classification: Medium Duty.
16. Inlet Fitting: Duco-cast iron, with threaded inlet and No-Hub outlet.

2.15 ROOF DRAINS

A. Roof Drains, RD: Comply with [ASME A112.21.2M] [ASME A112.3.1].

1. Application: Main flat roof areas.
2. Available Products:
3. Products:

    a. Smith, Jay R. Mfg. Co.; 1010-C-R-U-CID.

4. Body Material: Cast iron.
5. Dimensions of Body: 16-inch.
6. Combination Flashing Ring and Gravel Stop: Required.
7. Outlet: Bottom.
8. Dome Material: Cast iron.
9. Expansion Joint: Required.
10. Extension Collars: Required .
11. Underdeck Clamp: Required .

12. Sump Receiver: Required.

B. Roof Drains, RD: Comply with [ASME A112.21.2M] [ASME A112.3.1].

1. Application: Canopy/Atrium gutter drain.
2. Available Products:
3. Products:

   a. Smith, Jay R. Mfg. Co.; 1630T-U.

4. Body Material: Cast iron.
5. Dimensions of Body: 6-inch.
6. Combination Flashing Ring and Gravel Stop: Required.
7. Outlet: Bottom.
8. Dome Material: Cast iron.
9. Extension Collars: Required.
10. Expansion Joint: Required.
11. Underdeck Clamp: Required .
12. Sump Receiver: Not Required.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" 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 pressure regulators with inlet and outlet shutoff valves and balance valve bypass. Install pressure gages on inlet and outlet.

D. Install strainers on supply side of each control valve, pressure regulator, and solenoid valve.

E. Install 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.

F. Install backwater valves in building drain piping. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.

G. Install expansion joints on vertical risers, stacks, and conductors if indicated.

H. 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 (DN 100). Use NPS 4 (DN 100) 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 (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
4. Locate at base of each vertical soil and waste stack.

I. Install cleanout deck plates with top flush with finished floor, for floor cleanouts for piping below floors.

J. Install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall, for cleanouts located in concealed piping.

K. Install flashing flange and clamping device with each stack and cleanout passing through floors with waterproof membrane.

L. Install vent flashing sleeves on stacks passing through roof. Secure over stack flashing according to manufacturer's written instructions.

M. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
2. 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 (750 mm) or Less: Equivalent to 1 percent slope, but not less than 1/4-inch (6.35-mm) total depression.
b. Radius, 30 to 60 Inches (750 to 1500 mm): Equivalent to 1 percent slope.
c. Radius, 60 Inches (1500 mm) or Larger: Equivalent to 1 percent slope, but not greater than 1-inch (25-mm) total depression.

3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

N. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.

1. Install roof-drain flashing collar or flange so no leakage occurs between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
2. Position roof drains for easy access and maintenance.

O. Fasten wall-hanging plumbing specialties securely to supports attached to building substrate if supports are specified and to building wall construction if no support is indicated.

P. Fasten recessed-type plumbing specialties to reinforcement built into walls.

Q. Install wood-blocking reinforcement for wall-mounting and recessed-type plumbing specialties.

R. Install individual shutoff valve in each water supply to plumbing specialties. Use ball, gate, or globe valve if specific valve is not indicated. Install shutoff valves in accessible locations. Refer to Division 15 Section "Valves" for general-duty ball, butterfly, check, gate, and globe valves.

S. Install air vents at piping high points. Include ball, gate, or globe valve in inlet [and drain piping from outlet to floor drain].

T. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

U. 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 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Connect plumbing specialties to piping specified in other Division 15 Sections.

D. Ground equipment.

E. 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.

F. Connect plumbing specialties and devices that require power according to Division 16 Sections.

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each [backflow preventer] [thermostatic water mixing valve] [water tempering valve] [trap seal primer system].

1. Text: 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.
2. Refer to Division 15 Section "[Basic Mechanical Materials and Methods] [Mechanical Identification]" for nameplates and signs.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled [trap seal primer systems] and their installation, including piping and electrical connections. Report results in writing.

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain [trap seal primer systems] [interceptors]. Refer to Division 1 Section "[Closeout Procedures] [Demonstration and Training]."

END OF SECTION 15430

SECTION 15441 - WATER DISTRIBUTION PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes pumps for the building potable-water systems.

B. Related Sections include the following:

1. Division 15 Section "Packaged Booster Pumps" for booster systems.
2. Division 15 Section "HVAC Pumps" for hydronic system pumps.
3. Division 16 Sections for power-supply wiring, field-installed disconnects, electrical devices, and motor controllers.

1.3 SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities of selected models; shipping, installed, and operating weights; furnished specialties; and accessories for each type and size of pump specified. Indicate pumps' operating point on curves.

B. Shop Drawings: Show layout and connections for pumps. Include setting drawings with templates, directions for installation of foundation and anchor bolts, and other anchorages.

1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Maintenance Data: For each pump specified to include in maintenance manuals specified in Division 1.

D. Acceptable Substitute Manufacturers: All bidders desiring to furnish equipment other than that specified must submit a complete verification specification for the substituted equipment along with literature, wiring diagrams, piping diagrams, and a list of similar sized installations where proposed equipment is installed. The complete submittal must be presented to the Architect at least (7) full working days prior to the bid opening for approval. Substitutions will not be permitted after the contract has been awarded. Refer to Specification Section 01300, SUBMITTALS AND SUBSTITUTIONS.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of pumps through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, connections, and dimensional requirements of pumps and are based on specific manufacturer types and models indicated. Other manufacturers' pumps with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."

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.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

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. In-Line Circulators:

a. ITT Bell & Gossett Div.

2.2 PUMPS, GENERAL

A. Description: Factory-assembled and -tested, single-stage, centrifugal pump units; complying with UL 778; suitable for potable-water service; with all-bronze or stainless-steel construction and components in contact with water made of corrosion-resistant materials.

B. Motors: Comply with requirements in Division 15 Section "Motors" with built-in thermal-overload protection appropriate for motor size and duty.

C. End Connections for NPS 2 (DN50) and Smaller: Threaded. Pumps available only with flanged ends may be furnished with threaded companion flanges.

D. End Connections for NPS 2-1/2 (DN65) and Larger: Flanged.

E. Finish: Manufacturer's standard paint applied to factory-assembled and -tested units before shipping.

F. 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.

2.3 IN-LINE CIRCULATORS

A. Description: B&G PD-37 Horizontal in-line circulator, rated for 125-psig (860-kPa) minimum working pressure and minimum continuous water temperature of 225 deg F (107 deg C).

1. Construction: Radially split, all-bronze casing.
2. Impeller: ASTM B 36/B 36M, rolled brass; overhung, single suction, and keyed to shaft.
3. Seal: Mechanical.
4. Shaft and Sleeve: Steel shaft, with oil-lubricated copper sleeve.
5. Pump Bearings: Oil-lubricated, bronze-journal or thrust type.
6. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
7. Motor: ¾-hp, Single speed, with oil-lubricated bearings, unless otherwise indicated; and resiliently mounted to pump casing.

    a. Motor Size: For motors larger than 1/2 hp, select motor size that will not overload through full range of pump performance curve.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water distribution piping to verify actual locations of connections before pump installation.

3.2 INSTALLATION

A. Install pumps according to manufacturer's written instructions and with access for periodic maintenance, including removing motors, impellers, couplings, and accessories.

B. Support pumps and piping so weight of piping is not supported by pumps.

C. Suspend horizontal in-line pumps independent of piping. Use continuous-thread hanger rods and vibration isolation hangers of sufficient size to support pump weight. Fabricate brackets or supports as required. Refer to Division 15 Section "Hangers and Supports" for materials.

D. Suspend vertical in-line pumps independent of piping. Use continuous-thread hanger rods and vibration isolation hangers of sufficient size to support pump weight. Refer to Division 15 Section "Hangers and Supports" for materials.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:

1. Connect water distribution piping to pumps. Install suction and discharge pipe equal to or greater than size of pump nozzles. Refer to Division 15 Section "Water Distribution Piping."
2. 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 15 Section "Valves" for general-duty valves and Division 15 Section "Plumbing Specialties" for strainers.
3. 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 15 Section "Meters and Gages" for pressure gages and gage connectors.

B. Electrical wiring and connections are specified in Division 16 Sections.

C. Ground equipment.

1. 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.

3.4 COMMISSIONING

A. Check suction piping connections for tightness.

B. Clean strainers on suction piping.

C. Controls: Set for automatic starting and stopping operation.

D. Final Checks before Starting: Perform the following preventive maintenance operations:

1. Lubricate oil-lubricated-type bearings.
2. Verify that pump is free to rotate by hand and that pump for handling hot liquids is free to rotate with pump hot and cold. Do not operate pump if it is bound or drags, until cause of trouble is determined and corrected.
3. Verify that pump controls are correct for required application.

E. Starting procedure for pumps is as follows:

1. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
2. Open circulating line valve if pump should not be operated against dead shutoff.
3. Start motor.
4. Open discharge valve slowly.
5. Check general mechanical operation of pump and motor.
6. Close circulating line valve once there is sufficient flow through pump to prevent overheating.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain pumps as specified below:

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining pumps.
2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner with at least seven days' advance notice.

END OF SECTION 15441

SECTION 15446 - SUMP PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes sump pumps for the building storm drainage systems.

B. Related Sections include the following:

1. Division 15 Section "Motors" for sump pump motors.

1.3 SUBMITTALS

A. Product Data: Include performance curves, furnished specialties, and accessories for each type and size of pump indicated.

B. Shop Drawings: Show layout and connections for pumps. Include setting drawings with templates, directions for installing foundation and anchor bolts, and other anchorages.

1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Maintenance Data: For each type and size of pump specified to include in maintenance manuals specified in Division 1.

D. Acceptable Substitute Manufacturers: All bidders desiring to furnish equipment other than that specified must submit a complete verification specification for the substituted equipment along with literature, wiring diagrams, piping diagrams, and a list of similar sized installations where proposed equipment is installed. The complete submittal must be presented to the Architect at least (7) full working days prior to the bid opening for approval. Substitutions will not be permitted after the contract has been awarded. Refer to Specification Section 01300, SUBMITTALS AND SUBSTITUTIONS.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, connections, and dimensional requirements of pumps and are based on specific manufacturer types and models indicated. Other manufacturers' pumps with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."

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.

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 rigging instructions for handling.

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. Submersible Sump Pumps:
   a. Stancor, Inc.

2.2 SUMP PUMPS, GENERAL

A. Description: Factory-assembled and -tested, single-stage, centrifugal, end-suction sump pump units complying with UL 778. Include motor, operating controls, and construction for permanent installation.

B. Discharge Pipe End Connections NPS 2 (DN50) and Smaller: Threaded. Pumps available only with flanged-end discharge pipe may be furnished with threaded companion flanges.

C. Discharge Pipe End Connections NPS 2-1/2 (DN65) and Larger: Flanged.

D. Motors: Single speed, with grease-lubricated ball bearings, and non-overloading through full range of pump performance curves.

E. Finish: Manufacturer's standard paint applied to factory-assembled and -tested units before shipping.

F. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembling and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

2.3 SUBMERSIBLE SUMP PUMP - ELEVATOR

A. Description: Submersible, direct-connected sump pump complying with HI 1.1-1.5 for submersible sump pumps.

1. Sump shall be constructed of concrete and located in the elevator pit by others. Coordinate location of elevator sump pit with G.C.

2. Provide Stancor SE-50 series, cast bronze, hermetically sealed, submersible type, ceramic-carbon shaft seal, all fasteners and external metal parts shall be constructed of stainless steel. Pump shall be rated to deliver 74 GPM at a head of 37-feet. Single phase motor shall have internal automatic resetting, thermal overload protection. Impeller shall be of Vortex non-clog design. Pumps shall be powered by heavy duty, totally enclosed motors with oversized sealed bearings.

3. Motors: 1/2HP, 460 volt, 3 Phase, 60 hertz, 3600 RPM.

4. Controls: Pumps shall be controlled by water level probe and oil-minder probe type level switch set for simplex operation.

5. Alarm System: Provide Stancor (115V/1PH) oil-minder control system with built-in audible and visual alarm, contact for remote alarm location, water level probe, oil-minder probe, oil-minder power cable, probe cable, high liquid alarm cable, clamp device, NEMA 4X enclosure, alarm light, silence switch.

6. The control panel shall require a single electrical connection provided under Division 16.

7. Valves: Provide polypropylene foot valves, ball valves, and check valves.

8. Installation: Components and instrumentation for the pump system shall be furnished, ready for installation from a single source.

9. Install the system in strict accordance with the manufacturers recommendations and shop drawings.

10. Insurance: The system manufacturer shall include a Certificate of Insurance with their submittals, proving that they are insured as a manufacturer of such systems.

11. System Maintenance: The system manufacturer shall be capable of providing a maintenance agreement with the Owner.

12. System Wiring: The system manufacturer shall provide wiring of system components at the site. Wiring shall be performed by a licensed electrician and run in conduit.

2.4 SUBMERSIBLE SUMP PUMPS – GROUND WATER

A. Description: Submersible, direct-connected sump pump complying with HI 1.1-1.5 for submersible sump pumps.

1. Pump Arrangement: Duplex.
2. Casing: Cast iron with cast-iron inlet strainer, legs that elevate pump to permit flow into impeller, and discharge companion flange suitable for plain-end pipe connection arranged for vertical discharge.
3. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, open nonclog design, overhung, single suction, keyed to shaft, and secured by locking cap screw.
4. Construction: Stainless steel with stainless-steel or other corrosion-resistant impeller, stainless-steel inlet strainer, legs that elevate pump to permit flow into impeller, and discharge companion flange suitable for plain-end pipe connection arranged for vertical discharge.
5. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings.
6. Seals: Double mechanical seals.
7. Motor: 2-HP, Hermetically sealed, capacitor-start type, with built-in overload protection; and three-conductor waterproof power cable of length required, with grounding plug and cable-sealing assembly for connection at pump.
8. Moisture-Sensing Probe: Internal moisture sensor, moisture alarm, and waterproof cable of length required, with cable-sealing assembly for connection at pump.
9. Pump Discharge Piping: Factory or field fabricated, ASTM A 53, Schedule 40, galvanized-steel pipe, bronze pipe, or copper tube.
10. Basin Cover: Cast iron or steel and suitable for supporting controls. Refer to "Sump Pump Basins" Article for other requirements.
11. Controls: NEMA 250, Type 1 enclosure, pedestal mounted, unless wall mounting is indicated; with three mercury-float switches in NEMA 250, Type 6 enclosures; mounting rod; and electric cables. Include automatic alternator to alternate operation of pump units on successive cycles and to operate both units if one pump cannot handle load.
12. Float-Guide Pipe: Guide pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
13. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mercury-float-switch alarm matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell, unless battery operation is indicated.

2.5 GENERAL-DUTY VALVES

A. Refer to Division 15 Section "Valves" for general-duty gate, ball, butterfly, globe, and check valves. Use valves specified for domestic water, unless otherwise indicated. Include features and devices indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of plumbing piping systems to verify actual locations of piping connections before pump installation.

3.2 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Division 2 Section "Earthwork."

3.3 CONCRETE

A. Install concrete bases of dimensions indicated for sump pumps. Refer to Division 3 Section "Cast-in-Place Concrete" and Division 15 Section "Basic Mechanical Materials and Methods."

B. Concrete for pits and sumps is specified in Division 3 Section "Cast-in-Place Concrete."

3.4 INSTALLATION

A. Install pumps according to manufacturer's written instructions.

B. Install pumps and arrange to provide access for maintenance, including removal of motors, impellers, couplings, and accessories.

C. Support piping so weight of piping is not supported by pumps.

D. Wet-Pit-Mounted, Vertical Sump Pumps: Suspend pumps from basin covers. Make direct connections to storm drainage piping.

E. Submersible Sump Pumps: Set pumps on basin, pit, or sump floor. Make direct connections to storm drainage piping.

F. Sump Pump Basins: Install basins and connect to storm drainage piping. Brace interior of basins according to manufacturer's written instructions to prevent distortion or col-

lapse during concrete placement. Set basin cover and fasten to basin top flange. Install so top surface of cover is flush with finished floor.

G. Sump Pump Pits: Construct concrete pits and connect to storm drainage piping. Refer to Division 3 Section "Cast-in-Place Concrete" for concrete work. Set basin cover and fasten to top edge of concrete pit. Install so top surface of cover is flush with finished floor.

H. Packaged Drainage Pump Units: Install and make direct connections to storm drainage piping.

3.5 CONNECTIONS

A. Storm drainage piping installation requirements are specified in Division 15 Section "Drainage and Vent Piping." Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:

1. Install discharge pipe sizes equal to or greater than diameter of pump nozzles, and connect to storm drainage piping.
2. Install swing check valve and gate or ball valve on each sump pump discharge. Include spring-loaded or weighted-lever check valves for piping NPS 2-1/2 (DN65) and larger.
3. Install swing check valve and gate or ball valve on each automatic, packaged pump discharge.

B. Install electrical connections for power, controls, and devices.

C. Electrical power and control components, wiring, and connections are specified in Division 16 Sections.

D. Ground equipment.

1. 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 ADJUSTING

A. Pump Controls: Set pump controls for automatic start, stop, and alarm operation as required for system application.

3.7 COMMISSIONING

A. Final Checks before Starting: Perform the following preventive maintenance operations:

1. Lubricate bearings.
2. Disconnect couplings and check motors for proper direction of rotation.
3. Verify that each pump is free to rotate by hand. Do not operate pump if it is bound or drags, until cause of trouble is determined and corrected.
4. Verify that pump controls are correct for required application.

B. Starting procedure for pumps with shutoff power not exceeding safe motor power is as follows:

1. Start motors.
2. Open discharge valves slowly.
3. Check general mechanical operation of pumps and motors.

END OF SECTION 15446

SECTION 15487 - DOMESTIC WATER HEAT EXCHANGERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following for domestic water systems:

1. Instantaneous water heaters.
2. Accessories.

1.3 SUBMITTALS

A. Product Data: For each type and size of heat exchanger. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

B. Shop Drawings: Detail heat-exchanger 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. Differentiate between manufacturer-installed and field-installed wiring.

C. Product Certificates: Signed by manufacturers of heat exchangers certifying that products furnished comply with requirements.

D. Maintenance Data: For heat exchangers to include in maintenance manuals specified in Division 1.

E. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of heat exchangers through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of heat exchangers and are based on specific units indicated. Other manufacturers' products complying with requirements may be considered. Refer to Division 1 Section "Substitutions."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASME Compliance: Fabricate and label heat-exchanger, hot-water storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

E. ASHRAE Standard: Comply with performance efficiencies prescribed in ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

1.5 WARRANTY

A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of heat exchangers that fail in materials or workmanship within specified warranty period.

C. Warranty Period: 1-year material/wokmanship.

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. Instantaneous Water Heaters:

   a. Patterson-Kelley Company.

2. Expansion Tanks:

a. Amtrol, Inc.
b. Taco, Inc.
c. Bell & Gossett, Inc.

2.2 INSTANTANEOUS WATER HEATERS

A. Description: Two, Packaged, commercial, indirect-fired water heater with negligible storage capacity; and heat exchanger for heating water with steam. Model No. PKD10, each heat exchanger shall provide 60-GPM based on 40°F-140°F temperature rise with steam valve at 10-PSIG and 5-PSIG in the tubes.

B. Construction: ASME code, with 155-psig at 210°F in the shell and 150-psig at 20°F above the operating steam temperature in the tube circuit. Include nozzle or other arrangement for heat exchanger.

C. Heat Exchanger: Carbon steel shell for steam and straight, 16 BWG admirality brass tubes and tube sheet.

1. Pressure Rating: Equal to or greater than steam supply pressure.
2. Tappings: Factory fabricated of materials compatible with water heater shell for piping connections, relief valve, pressure gage, thermometer, blowdown, vent, and controls as required. Attach tappings to shell before testing and labeling.

    a. NPS 2 (DN50) and Smaller: Threaded ends according to ASME B1.20.1, pipe threads.
    b. NPS 2-1/2 (DN65) 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.

D. Temperature Control: Feed forward differential pressure diaphragm control valve is capable of maintaining outlet-water temperature within 5 deg F (2.8 deg C) of setting.

E. Safety Control: Automatic, high-temperature-limit cutoff device or system.

F. Miscellaneous Components: Strainer, steam trap, valves, piping, and thermostatic mixing valve.

G. Stand: Factory fabricated for floor mounting not to exceed 34-inch width.

2.3 EXPANSION 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.

B. Construction: **150-psig (1035-kPa)** working-pressure rating.

C. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1, pipe thread.

D. Tank Interior Finish: Materials and thicknesses complying with NSF 61, barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.

E. Tank Exterior Finish: Manufacturer's standard, unless otherwise indicated.

F. Air-Charging Valve: Factory installed.

2.4 HEAT-EXCHANGER ACCESSORIES

A. Combination Temperature and Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include relieving capacity at least as great as heat input and include pressure setting less than heat-exchanger working-pressure rating. Select relief valve with sensing element that extends into tank.

1. Option: Separate temperature and pressure relief valves are acceptable instead of combination relief valve.

B. Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include pressure setting less than heat-exchanger working-pressure rating.

C. Vacuum Relief Valves: Comply with ASME PTC 25.3. Furnish for installation in piping.

1. Exception: Omit if heat exchanger has integral vacuum-relieving device.

PART 3 - EXECUTION

3.1 CONCRETE BASES

A. Install concrete bases of dimensions indicated. Refer to Division 3 Section "Cast-in-Place Concrete" and Division 15 Section "Basic Mechanical Materials and Methods."

3.2 HEAT-EXCHANGER INSTALLATION

A. Install heat exchangers on concrete bases, 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.

B. Anchor heat exchangers to substrate.

C. Install seismic restraints for heat exchangers. Anchor to substrate.

D. Install temperature and pressure relief valves in top portion of storage tank shells of heat exchangers with storage. Use relief valves with sensing elements that extend into shells. Extend relief valve outlet with water piping in continuous downward pitch and discharge onto closest floor drain.

E. Install pressure relief valves in water piping for heat exchangers without storage. Extend relief valve outlet with water piping in continuous downward pitch and discharge onto closest floor drain.

F. Install vacuum relief valves in cold-water-inlet piping.

G. Install vacuum relief valves in heat-exchanger, storage tank shells that have copper lining.

H. Install heat-exchanger drain piping as indirect waste to spill into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 15 Section "Plumbing Specialties" for drain valves.

I. Install thermometers on heat-exchanger inlet and outlet piping. Refer to Division 15 Section "Meters and Gages" for thermometers.

J. Install pressure gages on heat-exchanger piping. Refer to Division 15 Section "Meters and Gages" for pressure gages.

K. Fill heat exchanger with water.

L. Charge compression tank with air.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to heat exchangers to allow service and maintenance.

C. Connect hot- and cold-water piping with shutoff valves and unions. Connect hot-water-circulating piping with shutoff valve, check valve, and union.

D. Connect steam and condensate piping with shutoff valves and unions.

E. Make connections with dielectric fittings where piping is made of dissimilar metal.

F. Electrical Connections: Power wiring and disconnect switches are specified in Division 16 Sections. Arrange wiring to allow unit servicing.

G. Ground equipment.

1. 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.

3.4 FIELD QUALITY CONTROL

A. Engage a factory-authorized service representative to perform startup service.

B. In addition to manufacturer's written installation and startup checks, perform the following:

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment and retest until satisfactory results are achieved.
2. Verify that piping system tests are complete.
3. Check for piping connection leaks.
4. Check for clear relief valve inlets, outlets, and drain piping.
5. Check operation of circulators.
6. Test operation of safety controls, relief valves, and devices.
7. Energize electric circuits.
8. Adjust operating controls.
9. Adjust hot-water-outlet temperature settings. Do not set above 140 deg F (60 deg C) unless piping system application requires higher temperature.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers.

1. Train Owner's maintenance personnel on procedures for starting and stopping, troubleshooting, servicing, and maintaining equipment.
2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15487

SECTION 15710 - HEAT EXCHANGERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes shell-and-tube heat exchangers for HVAC applications.

1.3 SUBMITTALS

A. General: Comply with pertinent provisions of Division 1 Section - "Submittals and Substitutions" and Division 15 Section - "Basic Mechanical Materials and Methods".

B. Product Data: Include rated capacities and pressure drop; shipping, installed, and operating weights; furnished specialties; and accessories for each heat exchanger. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Coordination Drawings: Comply with pertinent provisions of Division 1 Section - "Special Provisions" and Division 15 Section - "Basic Mechanical Materials and Methods" for Coordination Drawing requirements related to heat exchangers.

D. Maintenance Data: List of parts for each type of heat exchanger and troubleshooting maintenance guide to include in the maintenance manuals specified in Division 1 and Division 15 – "Basic Mechanical Materials and Methods".

1.4 QUALITY ASSURANCE

A. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide shell and tube heat exchangers by one of the following:

1. Shell-and-Tube Heat Exchangers:

a. ITT Fluid Handling; Div. of ITT Fluid Technology Corp.
b. Taco, Inc.
c. Amtrol, Inc.
d. Dunham-Bush, Inc.
e. Patterson-Kelley Co.; Div. of Harsco Corp.

2.2 CONFIGURATION AND RATINGS

A. Maximum Temperature: 375 deg F (190 deg C).

B. Maximum Shell Pressure: 150 psig (1551 kPa).

C. Maximum Tube Pressure: 150 psig (2068 kPa).

D. Heat Exchanger Type: Heating and heated medium shall be as indicated on the Drawings.

E. Configuration: Number of passes shall be as indicated on the Drawings.

F. Heat Exchanger Capacity Computation: Heat exchanger surfaces shall be computed based upon appropriate fouling factors for fluid, temperature, and tube velocity as recommended by the Standards of Tubular Exchanger Manufacturer's Association, except when specifically indicated otherwise on the Drawings.

2.3 CONSTRUCTION

A. Shell and Head Materials: Steel shell and cast-iron head.

B. Tube and Tube Sheet Materials: Seamless, 3/4-inch (20-mm) OD copper tubes with steel tube sheets.

C. Piping Connections: Flanged shell and head port connections for all piping 3" and larger and threaded shell and head ports for all piping 2 ½" and smaller.

1. Provide threaded drain connection and threaded vent connection.

2.4 ACCESSORIES

A. Support Cradle: Provide steel or cast-iron mounting cradle.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.

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

3.2 HEAT EXCHANGER INSTALLATION

A. Install heat exchangers according to manufacturer's written instructions.

B. Install shell-and-tube heat exchangers on floor mounted angle-iron support frame in accordance with Division 15 Section "Hangers and Supports" and Division 15 Section "Mechanical Vibration and Seismic Controls". Secure heat exchanger saddle supports to angle-iron frame.

C. Install heat exchanger on saddle supports with a U-bracket bolted to saddle supports. Install with provisions to drain shell.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Maintain manufacturer's recommended clearances for service and maintenance. Install piping connections to allow service and maintenance of heat exchangers.

C. Install piping with threaded or flanged connections at heat exchangers.

1. Install unions in piping at all threaded connections.

D. Install shutoff valves at heat exchanger inlet and outlet connections.

E. Install relief valves on heat exchanger heated-fluid connection.

F. Install vacuum breaker at heat exchanger steam inlet connection.

G. Install thermometer wells, thermometers, and automatic temperature control wells at heat exchanger inlet and outlet (heated fluid) connections.

H. Install steam control valve assemblies and steam condensate trap assemblies as indicated on the Drawings.

3.4 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.5 COMMISSIONING

A. Verify that heat exchangers are installed and connected according to the Contract Documents.

B. Adjust flows and controls to deliver specified performance.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers as specified below:

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining heat exchangers.
2. Review data in the "Operating and Maintenance Manuals" specified in Division 1 Section "Submittals and Substitutions", in Division 1 Section "Contract Closeout", and Division 15 Section "Basic Mechanical Materials and Methods".
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15710

SECTION 15711 – PACKAGED HEAT TRANSFER MODULES (Unfired Steam Generators)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes packaged unfired steam generators for HVAC applications.

1.3 SUBMITTALS

A. Comply with pertinent provisions of Division 1 Section "Submittals and Substitutions" and Division 15 Section "Basic Mechanical Materials and Methods".

B. Product data for each packaged unfired steam generator including the following:

1. Packaged unfired steam generator capacity. Submit performance data indicating source steam input versus process steam output.
2. Heat exchanger and shell construction.
3. Process steam pressure drop at scheduled design conditions.
4. Source steam pressure drop at scheduled design conditions.
5. Unfired steam generator packaged controls including all alarms, diagnostics, display type, features, operator settings, control system features, and required interfaces with building control system.
6. Weights (shipping, installed, and operating).
7. Furnished accessories including:

    a. Thermal insulation and jacket, include all components insulated and thermal characteristics of insulation.
    b. Steam trap, including steam trap capacities and steam trap construction.
    c. Steam strainer construction.
    d. Pressure gages.
    e. Blowdown valves.
    f. Safety relief valves.
8. Installation and startup instructions.

C. Shop Drawings: Complete set of manufacturer's certified prints of packaged unfired steam generator assemblies, control panels, sections and elevations, and unit vibration isolation. Include the following:

1. Assembled unit dimensions.
2. Operating weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Wiring Diagrams: Power, signal, and control wiring. Differentiate clearly between manufacturer-installed wiring and field-installed wiring.

D. Coordination Drawings: Floor plans drawn to scale and coordinated with the following:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.
5. Pneumatic control air roughing-in requirements.

E. Operation and Maintenance Data: For each packaged unfired steam generator to include in the operating and maintenance manual specified in Division 1 Section "Submittals and Substitutions" and Division 15 Section "Basic Mechanical Materials and Methods".

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, performance, and dimensional requirements of packaged unfired steam generators and are based on the specific equipment indicated.

B. ASME Compliance: Fabricate and label packaged unfired steam generators to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

C. Source quality-control test reports.

D. Startup service reports.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver packaged unfired steam generators with protective crating and covering.

B. Store packaged unfired steam generators to prevent damage and protect from weather, dirt, fumes, water, and construction debris in clean dry space.

C. Handle packaged unfired steam generators according to manufacturer's written rigging and installation instructions for unloading, transporting, and setting in final location.

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 3.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide packaged unfired steam generators by one of the following:

1. Cemline Corporation, Cheswick, PA.
2. Patterson-Kelley Co.; Div. of Harsco Corp., East Stroudsburg, PA

2.2 GENERAL

A. Packaged unfired steam generator shall be of the U-tube design.

1. Generated steam in the shell and primary steam in the coils.

B. Packaged unfired steam generator shall be completely factory assembled and ready for connection of primary steam, primary condensate, process (generated) steam, vessel blowdown, drain, and feedwater.

C. All components that are exposed to the process (generated) steam shall be stainless steel.

2.3 SHELL-AND-TUBE CONSTRUCTION

A. Shell and Head Materials: Stainless-steel shell and cast iron or cast bronze heads.

B. Tube and Tube Sheet Materials: Tubes shall be 18 gauge, BWG 304 stainless steel, ¾" O.D.

1. Tube sheets shall be type 304 stainless steel.
2. Heat exchanger surfaces shall be computed based upon appropriate fouling factors for fluid, temperature, and tube velocity as recommended by the Standards of Tubular Exchanger Manufacturer's Association, except when specifically indicated otherwise on the Contract Documents.

2.4 JACKET AND INSULATION

A. Packaged unfired steam generator shell shall be insulated with 3" fiberglass insulation covered by a 20 gauge steel jacket with painted finish.

2.5 BASE

A. Packaged unfired steam generator shall be mounted on a welded steel base. Base shall allow for the primary condensate steam trap outlet to discharge a minimum of 18" above the unit base.

2.6 CONTROLS

A. Provide an electronic level controller consisting of a stainless steel water column wired to a factory installed feedwater solenoid valve. Provide a check valve factory installed between the feedwater valve and unfired steam generator.

1. Stainless steel water column shall be provided with gauge glass and trycocks.
2. Provide factory installed stainless steel blowdown piping from water column. Provide stainless steel ball type blowdown valve.
3. Electronic level controller shall be wired to an alarm bell and spare relay to signal the DDC Building Automation System in the event of low water condition.

B. Provide a high water cutoff including an electronic probe which shall close an air operated power to open, spring to close ball valve.

1. High water cut off shall close the factory installed ball valve in the event of a high water alarm.

C. Packaged unfired steam generator shall be provided with an independent steam pressure safety system that will automatically shut off the steam control valve if the steam pressure in the shell is 5 psig over the operating steam system pressure.

1. Refer to Contract Documents for operating steam system pressure.
2. Setting shall be adjustable.

D. Provide a pneumatically operated, fully modulating steam control valve to modulate the primary steam to maintain the desired output steam pressure within 2 PSIG of design setpoint.

1. Provide pneumatic operator suitable for use with 20 psig main control air. Pneumatic operator shall come complete with main air and controlled air signal pressure gauges.

E. Provide an automatic timed unfired steam generator blowdown system consisting of a 24-hour, 7-day time clock and a 2 to 180 second interval timer and solenoid valve for automatically blowing down the unfired steam generator.

1. Provide the automatic blowdown system factory wired to a NEMA 1 control cabinet. Provide control cabinet with a single point 120 volt power connection.

2.7 SAFETY RELIEF VALVES

A. Manufacturers: Subject to compliance with requirements, provide factory installed safety relief valves by one of the following:

1. Armstrong International, Inc.
2. Kunkle Inds. Inc.; Kunkle Valve Division.
3. Spirax Sarco, Inc.
4. Watts Industries, Inc.; Watts Regulators.
5. Spence Engineering Co.

B. Provide safety relief valves of size and capacity in accordance with ASME Boiler and Pressure Vessel Code Section I. Safety relief valve(s) shall be capable of relieving the total BTU output of the unfired steam generator.

C. Unfired steam generators with total capacity below 7,499 pounds per hour of generated steam shall be provided with safety valve(s) as follows:

1. Safety relief valves shall be bronze, Class 250, with threaded inlet and outlet; forged copper-alloy disc; fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.

D. Unfired steam generators with total capacity equal to or greater than 7,500 pounds per hour of generated steam shall be provided with safety valve(s) as follows:

1. Safety relief valves shall be cast iron, Class 250; forged copper-alloy disc with bronze nozzle; fully enclosed, cadmium-plated steel spring with adjustable pressure range and positive shutoff; raised-face flanged inlet and threaded outlet connections; factory set and sealed.

2.8 STEAM TRAPS

A. Manufacturers: Subject to compliance with requirements, provide factory installed steam traps by one of the following:

1. Spirax Sarco, Inc.
2. Dunham-Bush, Inc.
3. ITT Hoffman; ITT Fluid Technology Corp.
4. Armstrong International, Inc.

B. Provide a float and thermostatic steam trap at the outlet of the source steam coil. Steam trap shall be sized for the full capacity of the required source steam scheduled on the Contract Documents.

C. Provide a float and thermostatic steam trap before the source steam control valve to prevent condensate from damaging source steam control valve. Steam trap shall be sized for a minimum of 100 pounds per hour of condensate.

D. Float and thermostatic traps shall be ASTM A 126, cast-iron body and bolted cap; renewable, stainless-steel float mechanism with renewable, hardened stainless-steel head and seat; maximum operating pressure of 125 psig (860 kPa); balanced-pressure, stainless-steel or monel thermostatic bellow element.

1. Thermostatic air vent capable of withstanding 45 deg F (25 deg C) of superheat and resisting water hammer without sustaining damage.

2.9 STEAM STRAINER

A. Provide a Y-Pattern strainer ahead of the steam control valve. Strainer shall be full line size of the steam piping entering the unfired steam generator.

B. Strainer shall be 250-psig (1725-kPa) working steam pressure; ASTM A 126, Class B cast-iron body; stainless-steel screen, No. 20 mesh for NPS 2 (DN 50) and smaller and manufacturer's recommended perforations for NPS 2-1/2 (DN 65) and larger; tapped blowoff plug. Threaded connections for strainers NPS 2 (DN 50) and smaller and flanged connections for strainers NPS 2-1/2 (DN 65) and larger.

2.10 ACCESSORIES

A. Pressure Gauges: Provide factory installed steam pressure gauges with shut-off cocks. Steam gauges shall be provided for both the primary steam (tube-side) and the generated steam (shell-side).

B. Manual Blowdown Valves: Provide a 1-1/2" stainless steel ball valve and a 1-1/2" iron body, slow opening, blowdown valve piped in series

1. Provide factory installed stainless steel blowdown piping from bottom of shell to the blowdown valves.

C. Vacuum Breaker: Provide factory installed vacuum breaker.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of unfired steam generators.

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

3.2 UNFIRED STEAM GENERATOR INSTALLATION

A. Install unfired steam generators according to manufacturer's written instructions.

B. Install shell-and-tube unfired steam generators on housekeeping pads with provisions to drain shell.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Maintain manufacturer's recommended clearances for service and maintenance. Install piping connections to allow service and maintenance of unfired steam generators.

C. Install piping with flanged connections at unfired steam generators.

D. Install shutoff valves at unfired steam generator inlet and outlet connections.

E. Install pneumatic control air to the steam control valve.

3.4 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.5 COMMISSIONING

A. Verify that unfired steam generators are installed and connected according to the Contract Documents.

B. Adjust flows and controls to deliver specified performance.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain unfired steam generators as specified below:

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining unfired steam generators.

2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15711

SECTION 15736 - SELF-CONTAINED AIR-CONDITIONING UNITS (15 TONS AND SMALLER)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes packaged air-conditioning units with refrigerant compressors and controls, intended for indoor installations, with integral air-cooled condensers.

B. Related Sections include the following:

1. Division 15 Section "Mechanical Vibration Isolation and Seismic Restraints" for isolation pads, spring isolators, and seismic restraints.
2. Division 15 Section "Control Systems Equipment" for control devices not packaged with units.
3. Division 15 Section "Sequence of Operation" for control sequences affecting operation of units.

1.3 SUBMITTALS

A. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each type of product indicated.

B. Shop Drawings: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Samples for Initial Selection: Manufacturer's color charts consisting of units or sections of units showing the full range of colors available for units with factory-applied color finishes.

D. Maintenance Data: For self-contained air-conditioning units to include in maintenance manuals specified in Division 1.

E. Warranties: Special warranties specified in this Section.

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 COORDINATION

A. Coordinate size and location of concrete bases for units. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 3 Section "Cast-in-Place Concrete."

B. Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations specified in Division 7 Section "Roof Accessories."

1.6 WARRANTY

A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of self-contained air-conditioning units that fail in materials or workmanship within specified warranty period.

C. Warranty Period: five years from date of Substantial Completion.

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. Filters: One set of filters for each unit.
2. Fan Belts: One set of belts for each unit.

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. Integral Air-Cooled, Self-Contained Heat Pump Air-Conditioning Units:

a. Bard Manufacturing Co.
b. McQuay International.
c. Trane Co. (The); North American Commercial Group.

2.2 PACKAGED UNITS

A. Description: Self-contained, factory-assembled and -wired unit; consisting of cabinet, compressor, evaporator fan, evaporator coil, air filters, electric heating coil, economizer, low ambient kit, high static drive, oversized fan motor, power exhaust, controls; and fully charged with refrigerant and oil.

1. Condenser: Integral air cooled condenser.

B. Disconnect Switch: Provided and mounted on equipment in the field by others.

2.3 CABINET

A. Frame and Panels: Heavy gauge-steel with galvanized steel panels with baked-enamel finish in color selected by Architect, and with access doors or panels.

B. Insulation: Minimum 1/2-inch- (13-mm-) thick, acoustic duct liner on cabinet interior and control panel.

C. Drain Pan: Galvanized steel with corrosion-resistant coating.

D. Corrosion-Resistant Treatment: Zinc coating on unit interior and exterior.

2.4 EVAPORATOR FAN

A. Material: Galvanized steel.

B. Configuration: Double-width, double-inlet, forward-curved centrifugal fan; statically and dynamically balanced.

C. Drive: Belt, with fan mounted on permanently lubricated bearings.

D. Fan Sheaves: Cast-iron or steel sheaves, dynamically balanced, bored to fit shafts and keyed. Provided with adjustable idler-arm assembly for quick adjustment of fan belts and motor sheaves.

E. Motor Sheave: Variable and adjustable pitch selected so required rpm are obtained when set at midposition.

F. Rating: As recommended by the manufacturer or a minimum of one and one-half times name-plate rating of motor.

G. Motors: Multispeed, PSC type.

2.5 COMPRESSOR

A. Description: Hermetically sealed, 3600 rpm maximum, and resiliently mounted with positive lubrication and internal motor protection.

B. Compressor Type: Reciprocating.

2.6 EVAPORATOR COIL

A. Direct-Expansion Coil: Seamless copper tubes expanded into aluminum fins.

1. Corrosion-Resistant Treatment: Phenolic coating applied with multiple dips and baked.

B. Refrigeration Circuit: A separate circuit for each compressor, with externally equalized thermal-expansion valve, filter-dryer, and charging valves.

2.7 INTEGRAL AIR-COOLED CONDENSER

A. Description: Factory assembled and tested; consisting of condenser coil, fans and motors, and cabinet.

1. Condenser Coils: Aluminum-fin copper tube with integral subcooler; leak tested to 425 psig (2930 kPa).
2. Condenser Fans: Direct-drive propeller type with permanently lubricated motor with built-in thermal-overload protection.
3. Low Ambient Control: Cycles fans to permit operation down to 0 deg F (minus 18 deg C).

2.8 HEATING COIL

A. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.

2.9 AIR FILTERS

A. Disposable Filters: **2-inch- (50-mm-)** thick, glass-fiber, flat panel filters.

2.10 CONTROLS

A. Control Package: Factory wired, including contactor, high- and low-pressure cutouts, internal-winding thermostat for compressor, control-circuit transformer, and noncycling reset relay, defrost control, economizer controller, remote potentiometer for calibrating economizer, powered exhaust, motorized damper control and microprocessor controller that essentially controls all temperature related control algorithms.

B. Time-Delay Relay: Five-minute delay to prevent compressor cycling.

C. Adjustable Thermostat/System Selector Switch: Manual/Auto Changeover-Auto, Heat, Cool or Off System switch and adjustable thermostat to control the following:

1. Supply fan.
2. Compressor.
3. Condenser.
4. Electric heater.
5. Economizer

2.11 VENTILATION OPTIONS

A. Economizer: Damper assembly allowing induction of up to 100 percent outside air to maintain a selected mixed-air temperature; and exhaust damper and spring-return, low-voltage, modulating damper motor with minimum position adjustment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb. Install unit on 14" curb to allow for needed wall penetration and drain trap clearances.

B. Anchor units to structure.

C. Isolation: Mount cabinet and remote air-cooled condenser on rubber-in-shear pads for mounting under base of unit and mount on flashed in roof curb.

1. Minimum Static Deflection: [**1 inch (25 mm)**.

D. Install seismic restraints.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Unless otherwise indicated, connect piping with unions and shutoff valves to allow units to be disconnected without draining piping. Refer to piping system Sections for specific valve and specialty arrangements.

D. Ground equipment.

1. 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.

3.3 FIELD QUALITY CONTROL

A. Installation Inspection: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections, and to prepare a written report of inspection.

B. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new components, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 COMMISSIONING

A. Engage a factory-authorized service representative to perform startup service.

B. Verify that units are installed and connected according to the Contract Documents.

C. Lubricate bearings, adjust belt tension, and change filters.

D. Perform startup checks according to manufacturer's written instructions and do the following:

1. Fill out manufacturer's checklists.
2. Check for unobstructed airflow over coils.
3. Check operation of condenser capacity-control device.
4. Verify that vibration isolation devices and flexible connectors dampen vibration transmission to structure.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining units.
2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15736

SECTION 15752 - HUMIDIFIERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following type[s] of humidifiers:

1. Steam-injection humidifiers for application on ducted HVAC systems.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating weights, furnished specialties, and accessories.

B. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, and dispersion tubes.

C. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, and required clearances.

D. Maintenance Data: For humidifiers to include in maintenance manuals specified in Division 1.

1.4 COORDINATION

A. Coordinate location and installation of humidifiers in ducts. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Jacketed, Duct Mounted, Steam-Injection Humidifiers:

a. Armstrong International, Inc. – 1000 Series.
b. Dri-Steem Humidifier Co. –CS Series.

2.2 STEAM-INJECTION HUMIDIFIERS

A. Description: Steam valve, separator, and dispersion tube extending across entire width of duct and equipped with mounting brackets for both ends of tube.

B. Dispersion Tube: ASTM A 666, Type 304 stainless steel, jacketed; insulated with 1/2-inch (13-mm) fiberglass and stainless-steel jacket.

C. Control Valve: Stainless steel body and internal trim, valve shall have modified linear flow charateristics, normally closed valve seat and stem matched to deliver required steam flow. Valve shall provide full and accurate modulation of steam flow over the entire stroke of the valve.

1. Actuator: Electric actuator, self-contained, modulating, linear motor, actuator with 60-second full travel, with transformer and single-throw, double-pole contacts.

D. Steam Separator: Separating chamber shall be designed to remove water droplets and particulate matter larger than three microns when humidifier is operating at maximum capacity.

1. Material: Type 304 stainless steel.

E. Steam Trap: Inverted-bucket type, sized for maximum condensate flow.

1. Material: Type 304 stainless steel body and all internal parts shall be stainless steel.

F. Steam Strainer: Inlet Y-type steam strainer located before steam control valve.

1. Material: Type 304 stainless steel body and internal parts.

G. Optional Accessories: Include the following:

1. Temperature switch to prevent cold operation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.

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

3.2 HUMIDIFIER INSTALLATION

A. Install with required clearance for service and maintenance.

B. Install humidifiers with a minimum of 5 feet of straight ductwork downstream of dispersion tube before any branch duct take-off, diffuser, elbow, volume damper, or other object.

C. Seal humidifier dispersion-tube duct penetrations with flange.

D. Install drip leg upstream from steam trap, a minimum of 12 inches (300 mm) for proper operation of trap.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to machine to allow service and maintenance.
2. Install shutoff valve and strainer in humidifier supply line.

B. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

C. Ground equipment.

1. 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.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation. Report results in writing.

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: Start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain humidifiers.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15752

SECTION 15764 - RADIATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Baseboard radiators.
2. Convectors.
3. Finned-tube radiators.
4. Steel radiators.

1.3 SUBMITTALS

A. Product Data: Include specialties and accessories for each radiator type.

B. Shop Drawings: Show the following:

1. Plans, elevations, sections, and details.
2. Details of custom-fabricated enclosures indicating dimensions.
3. Required clearances.
4. Location and size of each field connection.
5. Enclosure joints, corner pieces, access doors, and other accessories.
6. Method of attaching hangers to building structure.
7. Unit schedules to include rated capacities, furnished specialties, and accessories.

C. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for units with factory-applied color finishes.

D. Maintenance Data: For radiators to include in maintenance manuals specified in Division 1.

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. Baseboard Radiators:

   a. Burnham Corp.; Hydronics Div.
   b. Edwards Engineering Corporation.
   c. Haydon Corp.
   d. Hydrotherm.
   e. Rosemex Products.
   f. Slant/Fin.
   g. Sterling Heating Equipment.
   h. Weil-McLain; a United Dominion Company.

2. Convectors:

   a. Burnham Corp.; Hydronics Div.
   b. Dunham-Bush, Inc.
   c. Engineered Air.
   d. Rosemex Products.
   e. Sterling Heating Equipment.
   f. Trane Company (The); North American Commercial Group.

3. Finned-Tube Radiators:

   a. Dunham-Bush, Inc.
   b. Engineered Air.
   c. Haydon Corp.
   d. Rosemex Products.
   e. Slant/Fin.
   f. Sterling Heating Equipment.
   g. Trane Company (The); North American Commercial Group.

4. Steel Radiators:

   a. Engineered Air.
   b. Radiant Technology, Inc.
   c. Runtal North America Inc.; Runtal Radiators Div.

2.2 BASEBOARD RADIATORS

A. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins, one tube end belled; with polypropylene element glides.

1. Tube Diameter: [**NPS 3/4 (DN 20)**] [**NPS 1 (DN 25)**] [**NPS 1-1/4 (DN 32)**].
2. Fin Size: [**4 by 4 inches (100 by 100 mm)**] <**Insert size**>.

B. Enclosures: One piece, minimum 0.030-inch- (0.75-mm-) thick steel, with full-height back, full-length damper, end panel, end caps, corners, and joiner pieces to snap together. Front panel shall be easily removable.

1. Enclosure Height: <**Insert height in inches (mm).**>
2. Finish: Factory-applied baked enamel in manufacturer's [**standard**] [**custom**] color.
3. Element Brackets: Galvanized steel to support front panel and element glide.

C. Capacity: As scheduled, based on 65 deg F (18 deg C) entering air temperature, [**180 deg F (82 deg C) average water temperature**] [**1-psig (6.9-kPa) steam**].

2.3 CONVECTORS

A. Convector Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and cast-iron headers; steel side plates and supports; factory-pressure tested at 100 psig (690 kPa) underwater.

B. Enclosures: Steel with exposed corners rounded; removable front panels with tamperproof fasteners braced and reinforced for stiffness.

1. Front and Top: 0.0598-inch- (1.5-mm-) thick steel.
2. Back and Ends: 0.0478-inch- (1.2-mm-) thick steel.
3. Insulation: 1/2-inch- (13-mm-) thick, fibrous glass on inside at front, sides, and back of enclosure.
4. Finish: Factory-applied baked enamel in manufacturer's [**standard**] [**custom**] color.
5. Damper: Knob-operated internal damper at enclosure outlet, if not thermostatically controlled.
6. Access Doors: Factory made, permanently hinged with Allen-head camlock fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure for otherwise inaccessible valves.
7. Enclosure Style: [**Sloped top**] [**Flat top with top grille**] [**Flat top with front grille**] [**with bottom inlet**] [**with bottom inlet grille**] <**Insert style or schedule**>.

C. Capacity: As scheduled, based on 65 deg F (18 deg C) entering air temperature, [**180 deg F (82 deg C) average water temperature**] [**1-psig (6.9-kPa) steam**].

2.4 FINNED-TUBE RADIATORS

A. Heating Elements: Seamless copper tubing suitable for soldered fittings, mechanically expanded into evenly spaced aluminum fins.

1. Tube Diameter: [**NPS 3/4 (DN 20)**] [**NPS 1 (DN 25)**] [**NPS 1-1/4 (DN 32)**].
2. Fin Size: [**4 by 4 inches (100 by 100 mm)**] <**Insert size**>.

B. Heating Elements: Steel tubing mechanically expanded into evenly spaced steel fins.

1. Tube Diameter: NPS 1-1/4 (DN 32).
2. Fin Size: **<Insert size.>**

C. Element Hangers: Ball-bearing cradle type with unrestricted longitudinal movement on enclosure brackets.

D. Enclosures: [**Galvanized**] [**Enameled**] steel with easily jointed components for wall-to-wall installation, rigidly supported on wall- or floor-mounting brackets.

1. Enclosures 18 Inches (450 mm) and Less in Height: 0.0478-inch- (1.2-mm-) thick steel.
2. Enclosures More Than 18 Inches (450 mm) in Height: 0.0598-inch- (1.5-mm-) thick steel.
3. Support Brackets: Locate at maximum 36-inch (1000-mm) spacing.
4. Finish: Factory-applied baked enamel in manufacturer's [**standard**] [**custom**] color.
5. Damper: Knob-operated internal damper at enclosure outlet, if not thermostatically controlled.
6. Access Doors: Factory made, permanently hinged with Allen-head camlock fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure for otherwise inaccessible valves.
7. Enclosure Style: [**Sloped top**] [**Flat top with top grille**] [**Flat top with front grille**] **<Insert style or schedule>**.

E. Capacity: As scheduled, based on 65 deg F (18 deg C) entering air temperature, [**180 deg F (82 deg C) average water temperature**] [**1-psig (6.9-kPa) steam**].

2.5 STEEL RADIATORS

A. Heating Elements: Steel, welded and formed into flat tube with [**0.048-inch (1.22-mm) wall thickness for 56-psig (386-kPa) working pressure**] [**0.058-inch (1.47-mm) wall thickness for 85-psig (585-kPa) working pressure**] [**0.078-inch (1.98-mm) wall thickness for 128-psig (881-kPa) working pressure**] **<Insert thickness/pressure rating>**. Bond elements to square, steel header pipes with minimum 0.109-inch (2.76-mm) thickness, with piping and vent connections.

B. Mounting: [**Wall brackets**] [**Floor posts**].

C. Finish: Factory-applied baked enamel in manufacturer's [**standard**] [**custom**] color.

D. Capacity: As scheduled, based on 65 deg F (18 deg C) entering air temperature, 180 deg F (82 deg C) average water temperature.

2.6 SOURCE QUALITY CONTROL

A. Factory test and rate baseboard radiators according to Hydronics Institute's "Testing and Rating Standard for Baseboard Radiation."

B. Factory test and rate finned-tube radiators according to Hydronics Institute's "Testing and Rating Standard for Finned-Tube (Commercial) Radiation."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install radiators level and plumb.

B. Install baseboard radiators according to Hydronics Institute's I=B=R 200, "Installation Guide for Residential Hydronic Heating Systems," and as follows:

1. Unless otherwise indicated, center [**heating elements**] [**and**] [**enclosure**] under windows.
2. Unless otherwise indicated, install enclosure continuously [**from wall to wall,**] around corners, using outside and inside corner fittings.
3. Join sections with splicer plates and filler pieces to provide continuous enclosure.
4. Install access doors in enclosures for access to valves and other fittings.
5. Terminate enclosures with manufacturer's end caps.

C. Install finned-tube radiators as follows:

1. Unless otherwise indicated, center [**heating elements**] [**and**] [**enclosure**] under windows.
2. Unless otherwise indicated, install enclosure continuously from wall to wall.
3. Unless otherwise indicated, install enclosure continuously around corners, using outside and inside corner fittings.
4. Join sections with splicer plates [**and filler pieces**] to provide continuous enclosure.
5. Install access doors for access to valves and other fittings.
6. Install air-seal gasketing between wall and enclosure mounting channel.
7. Terminate enclosures with manufacturer's end caps.

D. Install steel radiators as follows:

1. Unless otherwise indicated, center radiators under windows.
2. Connect radiators with flexible piping connections.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect hot-water units and components to piping according to Division 15 Section "Hydronic Piping."

C. Install shutoff valve on inlet and balancing valve on outlet.

D. Connect steam units and components to piping according to Division 15 Section "Steam and Condensate Piping."

1. Install shutoff valve on inlet; install steam trap and shutoff valve on outlet.

3.3 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect for damage to exposed finish. Repair damaged finish to match original finish.

END OF SECTION 15764

SECTION 15766 - CABINET UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes cabinet unit heaters.

1.3 SUBMITTALS

A. Product Data: Include 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. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
4. Submit a schedule showing the following information for each cabinet unit heater provided:

    a. Drawing designation (Item No.).
    b. Room location.
    c. Model number and discharge configuration.
    d. Shipping, installed, and operating weights.
    e. Fan CFM, motor horsepower, motor speed, motor voltage, and phase.
    f. Air entering and leaving conditions.
    g. Hot Water Coils: Coil capacity (MBH), number of rows, air pressure drop, water pressure drop, GPM, water entering and leaving temperatures.
    h. Accessories, specialties, and controls included for each cabinet unit heater.

C. Coordination Drawings: Comply with pertinent provisions of Division 1 Section "Special Provisions" and Division 15 Section "Basic Mechanical Materials and Methods" for Coordination Drawing requirements related to cabinet unit heaters. Show the following:

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. Size and location of access panels in hard ceilings to provide access to concealed units.
5. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for units with factory-applied color finishes.

E. Field Test Reports: Written reports of tests specified in Part 3 of this Section.

F. Maintenance Data: For cabinet unit heaters to include in maintenance manuals specified in Division 1. Include the following:

1. Maintenance schedules and repair parts lists for motors, coils, integral controls, and filters.

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 COORDINATION

A. Coordinate layout and installation of cabinet unit heaters and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1. Coordination Drawings: Comply with pertinent provisions of Division 1 Section "Special Provisions" and Division 15 Section "Basic Mechanical Materials andMethods" for Coordination Drawing requirements related to cabinet unit heaters.

2. Coordinate recessed, semi-recessed, and surface mounted cabinet unit heaters with wall and ceiling types.

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 (1) spare filter for each filter installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide hot water cabinet unit heaters by one of the following:

1. Sterling Radiator Division/Mestek, Inc.
2. Trane Company (The); North American Commercial Group.
3. Airtherm Manufacturing Company.
4. McQuay International.

2.2 CABINET UNIT HEATERS

A. Description: An assembly including filter, chassis, coil, fan, and motor in blow-through configuration with heating coil.

B. Configuration: Cabinet unit heaters shall be surface-mounted, semi-recessed, or recessed cabinet with mounting arrangement as indicated on the Drawings.

C. Air inlet and outlet configuration shall be as indicated on the Drawings.

2.3 MATERIALS

A. Chassis: Galvanized steel, with flanged edges.

B. Coil Section Insulation: 1-inch (25-mm) duct liner complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

1. Fire-Hazard Classification: Duct liner and adhesive shall have a maximum flame-spread rating of 25 and smoke-developed rating of 50 when tested according to ASTM E 84.

C. Cabinet: Removable 16-gage galvanized steel front panel, 18 gage galvanized steel top, end and back panels. Panels shall be fastened with tamperproof fasteners and key-operated access door.

D. Cabinet Finish: Bonderize, phosphatize, and flow-coat with baked-on primer with manufacturer's standard paint, in color selected by Architect, applied to factory-assembled and -tested cabinet unit heater before shipping.

2.4 COILS

A. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and with manual air vent. Coils shall be rated for a minimum working pressure of 300 psig (2068 kPa) and a maximum entering water temperature of 275 deg F (135 deg C), with manual air vent.

2.5 FAN

A. Centrifugal, with forward-curved, double-width wheels and fan scrolls made of galvanized steel or thermoplastic material; directly connected to motor.

2.6 FAN MOTORS

A. Refer to Division 15 Section "Motors" for general requirements for factory-installed motors.

B. Motors: Shaded-pole or permanent-split capacitor, multi-speed motor with integral thermal-overload protection and resilient mounts.

1. Connect motor to chassis wiring with plug connection.

2.7 ACCESSORIES

A. Disconnect switch for all cabinet unit heaters.

B. Steel sub-base for all floor mounted units, height as indicated.

C. Extended end pockets on vertical discharge units where required to install piping and piping accessories.

D. Duct collar on the inlet and/or outlet for all ducted cabinet unit heaters.

E. Steel recessing flanges for all recessed and semi-recessed cabinet unit heaters. Recessing flanges shall be suitable for recessing into ceiling or wall.

F. Filters: 1-inch- (25-mm-) thick, glass-fiber media in fiberboard frame.

2.8 CONTROLS

A. Control Devices:

1. Unit-mounted fan-speed switch.
2. Unit-mounted fan-speed switch and thermostat.

2.9 SOURCE QUALITY CONTROL

A. Test cabinet unit heater coils according to ASHRAE 33.

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 cabinet unit heaters level and plumb.

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Suspend cabinet unit heaters from structure with rubber-in-shear vibration isolators. Vibration isolators are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Unless otherwise indicated for hot water cabinet unit heaters:

1. Install shutoff ball valve, strainer, union, and drain in hot water supply piping to cabinet unit heaters.
2. Install shutoff ball valve, balancing valve, union, control valve, union and manual air vent in hot water return piping from cabinet unit heaters.

C. Install piping adjacent to machine to allow service and maintenance.

D. Ground equipment.

E. 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.

3.4 FIELD QUALITY CONTROL

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. Test and adjust controls and safeties.

B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.5 CLEANING

A. After installing units, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. After installing units, clean cabinet unit heaters internally according to manufacturer's written instructions.

C. Install new filters in each cabinet unit heater within two weeks after Substantial Completion.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15766

SECTION 15767 - PROPELLER UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes propeller unit heaters.

1.3 SUBMITTALS

A. Product Data: Include 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. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
4. Submit a schedule showing the following information for each propeller unit heater provided:

    a. Drawing designation (Item No.).
    b. Room location.
    c. Model number and discharge configuration.
    d. Shipping, installed, and operating weights.
    e. Fan CFM, motor horsepower, motor speed, motor voltage, and phase.
    f. Air entering and leaving conditions.
    g. Hot Water Coils: Coil capacity (MBH), number of rows, air pressure drop, water pressure drop, GPM, water entering and leaving temperatures.
    h. Steam Coils: Coil capacity (MBH), number of rows, air pressure drop, and steam inlet pressure.
    i. Accessories and specialties included for each propeller unit heater.

C. Field Test Reports: Written reports of tests specified in Part 3 of this Section.

D. Maintenance Data: For propeller unit heaters to include in maintenance manuals specified in Division 1. Include the following:

1. Maintenance schedules and repair parts lists for motors, coils, and integral controls.

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.

B. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.5 COORDINATION

A. Coordinate layout and installation of propeller unit heaters and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1. Coordination Drawings: Comply with pertinent provisions of Division 1 Section "Special Provisions" and Division 15 Section "Basic Mechanical Materials and Methods" for Coordination Drawing requirements related to propeller unit heaters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide propeller type hot water unit heaters by one of the following:

1. Trane Company (The); North American Commercial Group.

2. Sterling Radiator Division/Mestek, Inc.
3. Airtherm Manufacturing Company.
4. McQuay International.

2.2 UNIT HEATERS

A. Description: An assembly including casing, coil, fan, and motor in horizontal discharge configuration with horizontal, adjustable louvers in blow-through configuration.

2.3 MATERIALS

A. Casing: Galvanized steel, with removable panels.

B. Cabinet Finish: Bonderize, phosphatize, and flow-coat with baked-on primer and manufacturer's standard paint applied to factory-assembled and -tested propeller unit heater before shipping.

2.4 COILS

A. Hot-Water Coil: Copper tube, 0.031-inch (0.78-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering water temperature of 325 deg F (163 deg C), with manual air vent. Test for leaks to 375 psig (2690 kPa) underwater.

2.5 FAN

A. Propeller with aluminum blades directly connected to motor, with fan guard.

2.6 FAN MOTORS

A. Refer to Division 15 Section "Motors" for general requirements for factory-installed motors.

B. Motors, 1/2 hp and Smaller: Shaded-pole or permanent-split capacitor, motor with integral thermal-overload protection.

C. Motors, 3/4 hp and Larger: Totally enclosed with permanently lubricated ball bearings.

2.7 ACCESSORIES

A. Horizontal Configuration: Adjustable louver fin diffuser.

B. Unit mounted disconnect switch and contactor for remote electric thermostat control. Thermostat by Div 15900.

2.8 CONTROLS

A. Control Devices for Hot Water and Steam Unit Heaters:

1. Unit-mounted fan-speed switch and wall-mounting thermostat.

2.9 SOURCE QUALITY CONTROL

A. Test propeller unit heater coils according to ASHRAE 33.

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 rubber-in-shear vibration isolators. Vibration isolators are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."

D. Install wall-mounting thermostats and switch controls in electrical outlet boxes 60 inches above finished floor.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Unless otherwise indicated for hot water unit heaters:

1. Install shutoff ball valve, strainer, union, and drain in hot water supply piping to unit heaters.
2. Install shutoff ball valve, manual air vent, balancing valve, aquastat, and union in hot water return piping from unit heaters.

C. Unless otherwise indicated for steam unit heaters:

1. Install shutoff gate valve, strainer, and union, in steam supply piping to unit heaters.
2. Install a union and low-pressure float and thermostatic steam trap assembly in condensate return piping from unit heaters.

D. Install piping adjacent to unit heaters to allow service and maintenance.

E. Ground equipment.

F. 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.

3.4 FIELD QUALITY CONTROL

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. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safeties.

B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.5 CLEANING

A. After installing units, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. After installing units, clean propeller unit heaters internally according to manufacturer's written instructions.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain propeller unit heaters.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15767

SECTION 15769 - RADIANT HEATING PANELS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes hydronic radiant heating panels for space-heating applications.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, specialties, and accessories for each radiant panel type indicated on Drawings. Submit data indicating the capacity of radiant heating panels per square foot and the pressure drop per linear foot.

B. Shop Drawings: Include 1/8 inch scale plans, elevations, sections, details, and attachments to other Work. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Detail connections and indicate all circuiting and interconnection between panels.

C. Coordination Drawings: Comply with pertinent provisions of Division 1 Section - "Special Provisions", Division 15 Section - "Basic Mechanical Materials and Methods", and Division 15 Section - "Hydronic Piping" for general Coordination Drawing requirements related to radiant heating panels. Coordination Drawings shall show the following:

1. Location, size, and interconnecting piping for all radiant panels required on the Project.
2. Ceiling suspension assembly members.
3. Method of attaching hangers to building structure.
4. Size and location of access doors and access panels for acoustical tile and gypsum walls and ceilings.

D. Samples for Initial Selection: For each exposed radiant heating panel type and for each color and finish required.

E. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

F. Maintenance Data: For radiant heating panels to include in maintenance manuals specified in Division 1 and Division 15 Section - "Basic Mechanical Materials and Methods". Include data for the following:

1. Detailed manufacturer's instructions for cleaning.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Engage a firm experienced in manufacturing radiant heating panels similar to those indicated for this Project and that have a record of successful in-service performance.

1.5 COORDINATION

A. Coordinate layout and installation of radiant heating panels and suspension system components with the Architectural Reflected Ceiling Plans, Room Finish Schedule, Structural Drawings, Mechanical Drawings, Electrical Drawings, Plumbing Drawings, and Fire Protection Drawings. Coordinate construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1. Inform Architect of all conflicts between the Architectural Reflected Ceiling Plans, Room Finish Schedule, and the Mechanical Drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide radiant heating panels by one of the following:

1. Hydronic Radiant Heating Panels:

a. Airtex, ENGINEERED AIR; Desoto, Kansas.
b. Sun-El Corp.; Latrobe, Pennsylvania.
c. Shelley Radiant Ceiling Co.; Northfield, Illinois.
d. Sterling, Westfield,MA

2.2 HYDRONIC PANELS

A. Description: Linear extruded-aluminum radiant heating panel with copper water coil, mechanically attached to backside, suitable for lay-in installation flush with T-bar ceiling grid. Panels shall be designed to allow field modifications such as shortening overall length, and mitering. Panels shall have the following characteristics:

1. Copper Coil: NPS 1/2 (DN 15).
2. Nominal Size: Width, length as indicated on Drawings.
3. Minimum Heating Output: Capacities as indicated on Drawings.
4. Circuiting: As indicated on the Drawings.

B. Fabrication: Radiant panels shall be manufactured of extruded aluminum. Panel face configuration shall be fluted. The panel shall consist of interlocking extruded sections with steel channel cross braces attached by steel assembly clips. Each section shall have at least one integral heat saddle with a 0.50 inch copper tube mechanically reformed into the heat saddle such that the tube is in intimate engagement. A non-hardening heat conductive paste shall be applied between the copper tube and the aluminum extrusion or a top cap strip mechanically fastened into the tube saddle. The ends of the tubes shall be sized to accept type L or M soft copper tubing without the need for fittings.

C. Finish: 2 coats, polyester finish with 70 to 80 percent light-reflection value.

1. Color: Standard White.

D. Insulation Above Panels: 1-inch thick, 3/4-pcf density, fiberglass pads.

E. Panel Weight: No more than 1.5 lb/sq. ft. (7.34 kg/sq. m) when filled with water.

F. Interconnecting Tubing: Provide 360 degree pigtail interconnects and U-bends 0.500 inch inside diameter as required to interconnect panels.

G. Hold Down Clips: Provide hold down clips installed at wall channels and T-bars to secure the panel and provide a flat even appearance.

H. Recessed Mounting Frame: Furnish a recessed mounting frame suitable for installation in a plaster or gypsum wallboard ceiling where radiant ceiling panels are indicated to be installed in a plaster or gypsum wallboard ceiling.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive radiant heating panels for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for hot-water piping connections to verify actual locations before radiant heating panel installation.

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

3.2 INSTALLATION

A. Install radiant heating panels as indicated, to comply with manufacturer's written instructions.

B. Installation of radiant panels shall not begin until exterior glazing is completed, all exterior openings have been made weather-tight, roof has been made weather-tight, and all concrete and plastering work has thoroughly cured.

C. Install radiant heating panels level and plumb.

D. Hang or support radiant heating panels according to Division 15 Section "Hangers and Supports."

1. Hangers shall be installed not over 4 feet on center.
2. Panels shall be suspended from the structure as indicated on the Drawings.

E. Panels shall be trimmed to run wall to wall to minimize joints. Ensure adequate expansion allowance while maintaining panel end coverage by architectural moldings. In all cases the fluting on the abutting panel shall be aligned. Manufacturer shall furnish all special tools required for installation or modification of the panel. Inactive filler panels will be permitted only where indicated on the Drawings.

F. Install insulation above all active radiant heating panels.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Unless otherwise indicated, install shutoff valve, union, and pipe reducer/increaser at each radiant panel supply connection. Install shutoff valve, union, balancing valve, and pipe reducer/increaser at each radiant panel return connection.

C. Install piping to allow service and maintenance.

D. Install all interconnecting tubing between all panels.

E. Clean and flush all radiant panel piping and interconnecting tubing in accordance with Division 15 Sections - "Hydronic Piping" and "HVAC Water Treatment".

3.4 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing and report results in writing:

1. Testing: All interconnecting piping shall be pressure tested. Pressure test according to Division 15 Section "Hydronic Piping".

B. Remove and replace malfunctioning units with new units, and retest.

3.5 CLEANING

A. After installing panels, inspect radiant heating panels for damage to finish. Remove burrs, paint splatters and other spots, and dirt. Replace radiant panels that have damaged finishes.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain radiant heating panels.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15769

SECTION 15772 - RADIANT HEATING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes radiant heating piping, including pipes, fittings, and piping specialties for the following systems:

1. Radiant heating system serving the Atrium floor of the Patient Care Tower.
2. Radiant snowmelt system serving the sidewalk around the main Patient Care Tower entry provided under Alternate No. 11.

B. Related Sections include the following:

1. Division 7 Section "Through-Penetration Firestop Systems" for materials and installation requirements for sealing pipe penetrations through fire and smoke barriers.
2. Division 15 Section "Basic Mechanical Materials and Methods" for general piping materials and installation requirements.
3. Division 15 Section "Hangers and Supports" for pipe supports, product descriptions, and installation requirements.
4. Division 15 Section "Mechanical Identification" for labeling and identifying piping and equipment.
5. Division 15 Section "Valves" for general-duty gate, globe, ball, and check valves.
6. Division 15 Section "Hydronic Piping" for pipes and connections to hydronic systems.
7. Division 15 Section "HVAC Water Treatment" for propylene glycol required for snowmelt system (Alternate ???).
8. Division 15 Section "HVAC Instrumentation and Controls" for thermostats, controllers, automatic control valves, and sensors.

1.3 DEFINITIONS

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

B. PEX: Crosslinked polyethylene.

1.4 SUBMITTALS

A. Product Data: Radiant heating piping specialties, including rated capacities and water flow and pressure drops of selected models.

B. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies and their attachments to the building structure.

1. Indicate manifold locations, tubing spacing, and circuiting of tubing on layout.

C. Maintenance Data: For manifolds and control devices to include in maintenance manuals specified in Division 1.

1.5 COORDINATION

A. Coordinate layout and installation of radiant heating piping and suspension system with building and structural components.

B. Coordinate size and location of access panels to allow access to manifolds concealed in ceilings, walls, and floors.

C. Coordinate thickening of slabs where required for adequate encasement of radiant heating piping components.

D. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.

1.6 STORAGE AND DELIVERY

A. Store tubing shielded from direct sunlight.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Tubing:

a. Wirsbo Co.
b. Infloor Heating Systems.
c. Heatlink USA Inc.
d. Stadler – Viega.

2. Distribution Manifolds:

a. Wirsbo Co.
b. Infloor Heating Systems.
c. Heatlink USA Inc.
d. Stadler – Viega.

2.2 HEAT-TRANSFER PIPES AND FITTINGS

A. PEX Plastic: ASTM F 876 with an integral oxygen diffusion barrier conforming to DIN Standard D4726.

1. Fittings: ASTM F 1807, copper or brass compression type.
2. Tubing Size: As indicated on Drawings.

2.3 RADIANT HEATING SPECIALTIES

A. Distribution Manifolds: Cast brass modular design with main shutoff and balancing valves with thermometers, zone shutoff and balancing valves with flow meter, and identification plate.

1. Piping Loops: Manifold shall be provided with the number of piping loops as scheduled on the Drawings.
2. Identification Plate: Valve plate shall identify room served and loop number.
3. If more than one loop serves a room, provide identification plates on manifolds to identify rooms served.

PART 3 - EXECUTION

3.1 HEAT-TRANSFER PIPING INSTALLATION

A. Install piping, manifold and specialties in accordance with manufacturers recommendations.

B. Install piping downstream from manifolds without joints.

C. Secure piping in concrete floors by attaching pipes to concrete reinforcement or wire mesh reinforcement using plastic tie straps. Refer to architectural, civil, and structural drawings for installation details.

1. Install a sleeve of foam-type insulation around tubing and extending for a minimum of 3 inches (75 mm) on each side of the slab penetration to protect the tubing passing through expansion joints.

D. Install manifolds in accessible locations.

E. Snowmelt system (Alternate No. 11):

1. Fill system with 40 percent of propylene glycol-to-water solution.

3.2 FIELD QUALITY CONTROL

A. Prepare radiant heating piping for testing as follows:

1. Temporarily restrain expansion joints so they are not damaged due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
2. Flush with clean water, and clean strainers.
3. Install relief valve set at a pressure no more than one-third higher than test pressure.

B. Perform the following tests:

1. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig (690 kPa).
2. After hydrostatic test pressure has been applied, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
3. Upon completion of installation of all radiant heating piping and manifolds, the local representative shall inspect the completed project and certify in writing to the contractor that all systems are installed properly, or require correction. The contractor shall submit a report to the Architect, including the representative's report. Certifying correctness of the installation or detailing corrective work to be done.

3.3 ADJUSTING

A. After system balancing has been done, mark balancing (zone) valves to permanently indicate final position.

B. Perform the following adjustments before operating the system:

1. Open valves to fully open position. Close bypass valves.
2. Check operation of automatic valves.
3. Set temperature controls so all zones call for full flow.

3.4 CLEANING

A. After testing has been successfully completed, flush piping and clean strainer screens.

END OF SECTION 15772

SECTION 15815 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg (minus 500 to plus 2500 Pa). Metal ducts include the following:

1. Rectangular ducts and fittings.
2. Single-wall, round,and flat-oval spiral-seam ducts and formed fittings.

B. Related Sections include the following:

1. Division 15 Section "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
2. Division 15 Section "Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 DEFINITIONS

A. NUSIG: National Uniform Seismic Installation Guidelines.

1.4 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Architect. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.5 SUBMITTALS

A. Product Data: Submit product data for the following:

1. Duct fabrication standards indicating metal gauges, reinforcing, joint construction, gaskets, and methods of fabrication for each pressure classification and type of system.
2. Duct sealing materials, including material safety data sheets for each product.

B. Shop Drawings: CAD-generated and drawn to 1/4 inch equals 1 foot (1:50) scale. Show fabrication and installation details for metal ducts. Submit sheet metal fabrication drawings after all coordination with specialty trades is completed. Drawings shall indicate the following:

1. Definition: Sheet Metal fabrication drawings are the installation shop drawings normally prepared by the installing sheet metal sub-contractor.
2. Prepare sheet metal fabrication drawings in accordance with the requirements for coordination drawings as specified in Division 1 Section "Special Provisions" and Division 15 Section "Basic Mechanical Materials and Methods".
3. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
4. Duct layout indicating sizes and pressure classes.
5. Elevations of top and bottom of ducts.
6. Dimensions of main duct runs from building grid lines.
7. Duct fittings, transitions, and takeoffs.
8. Reinforcement and spacing.
9. Seam and joint construction.
10. Penetrations through fire-rated and other partitions.
11. Equipment including terminal boxes, humidifiers, coils, diffusers, grilles, fans, air handling units, air flow stations, and sound attenuators.
12. Duct accessories, including access doors and panels.
13. Volume, fire, smoke, and automatic control dampers.
14. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.
15. Duct smoke detectors.

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. Welding certificates.

E. Submit the following duct system schedule for testing on all systems listed in Part 3 of this Section:

1. Prepare and submit a schedule for duct system testing indicating specific dates and procedures. The Owner and Architect shall be notified a minimum of two (2) weeks before

testing is performed. Coordinate schedule with Section 15990 - "Testing, Adjusting, and Balancing".

2. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

F. Field quality-control test reports.

G. Record Drawings: Indicate actual routing, fitting details, reinforcement, support, and installed accessories and devices.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports, AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members, and 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. Mockups:

1. Before installing duct systems, build mockups of each duct system representing pressure classes higher than 2-inch wg (500 Pa). Build mockups to comply with the following requirements, using materials indicated for the completed Work, and include each of the following features and fittings:

   a. Five transverse joints.
   b. One access door(s).
   c. Two typical branch connections, each with at least one elbow.
   d. Two typical flexible duct or flexible connector connections for each duct and apparatus.
   e. Perform tests specified in Part 3 "Field Quality Control" Article. Modify mockup construction and perform additional tests as required to achieve specified minimum acceptable results.

2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver sealant and firestopping materials to site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

B. Store and handle sealant and firestopping materials according to manufacturer's written recommendations.

C. Deliver and store stainless-steel sheets with mill-applied adhesive protective paper maintained through fabrication and installation.

D. All pre-fabricated duct sections shall be cleaned prior to storage on the site and be provided with protective metal or polyethylene end caps on all openings to maintain the interior of the ductwork clean and free of dust and other materials prior to installation. Field-assembled duct sections shall be cleaned during assembly and similarly protected until installation.

1. Any ductwork that is not properly protected and cleaned in accordance with subparagraph "D", will require the entire supply, return, and/or exhaust duct system to be cleaned in accordance with NADCA (National Air Duct Cleaners Association) Standard – "Cleaning of Non-Porous Air Conveyance System Components" at no additional expense to the Owner.

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.

1.22.2 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. 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 (Z275) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.

D. Stainless Steel: ASTM A 480/A 480M, Type 316, and having a No. 2D finish for concealed ducts.

E. Aluminum Sheets: ASTM B 209 (ASTM B 209M), alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

G. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 SEALANT MATERIALS

A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and 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. Solvent-Based Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.

D. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

E. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.4 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 (100 mm) thick.
2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

B. Hanger Materials: Galvanized sheet steel or threaded steel rod.

1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
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 unless materials are electrolytically separated from ducts.

2.5 RECTANGULAR DUCT FABRICATION

A. Duct Construction System Type 1, Type 2, and Type 6:

1. Materials: Galvanized, sheet steel, lock-forming quality; ASTM A 653/A 653M, G90 (Z275) coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.
2. Pressure Class: Refer to "Sheet Metal Duct Construction Schedule".
3. Sealing Class: Refer to "Sheet Metal Duct Construction Schedule".
4. Duct Reinforcement (Up to 18 inch - greatest dimension): Reinforcement shall be in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible"/Table 1-5.
5. Duct Reinforcement (19 inch and larger - greatest dimension): Reinforcement shall be in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible"/Table 1-5 and shall be reinforced for a maximum allowable deflection for transverse joints and intermediate reinforcements not to exceed the following:

    a. 0.25 inch deflection for duct widths up to 100 inches
    b. 0.3 percent deflection of the span for duct widths over 100 inches

6. Longitudinal Seams: Seams shall be constructed in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Figure 1-5, Pittsburgh Lock Seam (L-1).
7. Transverse Joints (Up to 18 inch - greatest dimension): Joints shall be in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Figure 1-4.
8. Transverse Joints (19 inch and larger - greatest dimension): Joints shall be prefabricated slide on transverse joints with gasket. Slide on transverse joints shall be as manufactured by Ducmate Industries, or an approved equal.

    a. Provide a flange gasket for each joint. Flange gasket shall be a butyl rubber gasket that complies with UL Standard 181 and UL Standard 723 testing.

9. Fittings: Fittings shall be constructed in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Section II.

    a. Elbows shall be in accordance with Figure 2-2, Type RE 1 or Type RE 2.
    b. Branch connections shall be 45° entry Figure 2-6.
    c. Divided flow branches shall be in accordance with Figure 2-5, Type 3.
    d. Offsets and transitions shall be in accordance with Figure 2-7.

10. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches (480 mm) and larger and 0.0359 inch (0.9 mm) thick or less, with more than 10 sq. ft. (0.93 sq. m) of unbraced panel area.

B. Duct Construction System Type 3, Type 4, and Type 5:

1. Materials: Galvanized, sheet steel, lock-forming quality; ASTM A 653/A 653M, G90 (Z275) coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.
2. Pressure Class: Refer to "Sheet Metal Duct Construction Schedule".
3. Sealing Class: Refer to "Sheet Metal Duct Construction Schedule".
4. Duct Reinforcement: Reinforcement shall be in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Table 1-5.
5. Longitudinal Seams: Seams shall be constructed in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Figure 1-5.
6. Transverse Joints: Joints shall be in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Figure 1-4.
7. Fittings: Fittings shall be constructed in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Section II.

    a. Elbows shall be in accordance with Figure 2-2, Type RE 1 or Type RE 2.
    b. Branch connections shall be 45° entry Figure 2-6.
    c. Divided flow branches shall be in accordance with Figure 2-5, Type 3.
    d. Offsets and transitions shall be in accordance with Figure 2-7.

8. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches (480 mm) and larger and 0.0359 inch (0.9 mm) thick or less, with more than 10 sq. ft. (0.93 sq. m) of unbraced panel area.

C. Duct Construction System Type 7 and Type 11:

1. Materials: Aluminum Sheets: ASTM B 209 (ASTM B 209M), Alloy 3003, Temper H14, sheet form with mill finish. Aluminum gage thickness, reinforcement and dimension adjustments shall be in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Tables 1-21, 1-22, and 1-23.
2. Pressure Class: Refer to "Sheet Metal Duct Construction Schedule".
3. Sealing Class: Refer to "Sheet Metal Duct Construction Schedule".
4. Duct Reinforcement (Up to 18 inch - greatest dimension): Reinforcement shall be in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible"/Table 1-5.
5. Duct Reinforcement (19 inch and larger - greatest dimension): Reinforcement shall be in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible"/Table 1-5 and shall be reinforced for a maximum allowable deflection for transverse joints and intermediate reinforcements not to exceed the following:

    a. 0.25 inch deflection for duct widths up to 100 inches
    b. 0.3 percent deflection of the span for duct widths over 100 inches

6. Longitudinal Seams: Seams shall be constructed in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Figure 1-5, Pittsburgh Lock Seam (L-1).
7. Transverse Joints (Up to 18 inch - greatest dimension): Joints shall be in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Figure 1-4.
8. Transverse Joints (19 inch and larger - greatest dimension): Joints shall be prefabricated slide on transverse joints with gasket. Slide on transverse joints shall be as manufactured by Ducmate Industries, or an approved equal.

    a. Provide a flange gasket for each joint. Flange gasket shall be a butyl rubber gasket that complies with UL Standard 181 and UL Standard 723 testing.

9. Fittings: Fittings shall be constructed in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Section II.

    a. Elbows shall be in accordance with Figure 2-2, Type RE 1 or Type RE 2.
    b. Branch connections shall be 45° entry Figure 2-6.
    c. Divided flow branches shall be in accordance with Figure 2-5, Type 3.
    d. Offsets and transitions shall be in accordance with Figure 2-7.

10. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches (480 mm) and larger and 0.0359 inch (0.9 mm) thick or less, with more than 10 sq. ft. (0.93 sq. m) of unbraced panel area.

D. Duct Construction System Type 8:

1. Materials: Aluminum Sheets: ASTM B 209 (ASTM B 209M), Alloy 3003, Temper H14, sheet form with mill finish. Aluminum gage thickness, reinforcement and dimension adjustments shall be in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Tables 1-21, 1-22, and 1-23.
2. Pressure Class: Refer to "Sheet Metal Duct Construction Schedule".
3. Sealing Class: Refer to "Sheet Metal Duct Construction Schedule".
4. Duct Reinforcement: Reinforcement shall be in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Table 1-5.
5. Longitudinal Seams: Seams shall be constructed in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Figure 1-5.
6. Transverse Joints: Joints shall be in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Figure 1-4.
7. Fittings: Fittings shall be constructed in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Section II.

    a. Elbows shall be in accordance with Figure 2-2, Type RE 1 or Type RE 2.
    b. Branch connections shall be 45° entry Figure 2-6.
    c. Divided flow branches shall be in accordance with Figure 2-5, Type 3.
    d. Offsets and transitions shall be in accordance with Figure 2-7.

8. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches (480 mm) and larger and 0.0359 inch (0.9 mm) thick or less, with more than 10 sq. ft. (0.93 sq. m) of unbraced panel area.

E. Duct Construction System Type 9:

1. Materials: Galvanized, sheet steel, lock-forming quality; ASTM A 653/A 653M, G90 (Z275) coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.
2. Pressure Class: Refer to "Sheet Metal Duct Construction Schedule".
3. Sealing Class: Refer to "Sheet Metal Duct Construction Schedule".
4. Duct Reinforcement: Reinforcement shall be in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible"/Table 1-5 and shall be reinforced for a maximum allowable deflection for transverse joints and intermediate reinforcements not to exceed the following:

    a. 0.25 inch deflection for duct widths up to 100 inches

5. Longitudinal Seams: Seams shall be constructed in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Figure 1-5, Pittsburgh Lock Seam (L-1).
6. Transverse Joints: Joints shall be prefabricated slide on transverse joints with gasket. Slide on transverse joints shall be as manufactured by Ducmate Industries, or an approved equal.

    a. Provide a flange gasket for each joint. Flange gasket shall be a butyl rubber gasket that complies with UL Standard 181 and UL Standard 723 testing.

7. Fittings: Fittings shall be constructed in accordance with SMACNA - "HVAC Duct Construction Standards - Metal and Flexible" - Section II.

    a. Elbows shall be in accordance with Figure 2-2, Type RE 1 or Type RE 2.
    b. Branch connections shall be 45° entry Figure 2-6.
    c. Divided flow branches shall be in accordance with Figure 2-5, Type 3.
    d. Offsets and transitions shall be in accordance with Figure 2-7.

8. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches (480 mm) and larger and 0.0359 inch (0.9 mm) thick or less, with more than 10 sq. ft. (0.93 sq. m) of unbraced panel area.

F. Duct Construction System Type 10:

1. All joints shall be welded.

    a. Material: 20 ga sheet steel, fully welded.

    b. Pressure Class: Refer to "Sheet Metal Duct Construction Schedule".

c. Provide a flange gasket for each flange connection as shown on detail. Flange gasket shall be a butyl rubber gasket that complies with UL Standard 181 and UL Standard 723 testing.

d. Provide access door per specification section.

e. Prime and paint.

PART 3 - EXECUTION

3.1 SHEET METAL DUCT CONSTRUCTION SCHEDULE

A. All ductwork shall be constructed in accordance with the following schedule. Pressure, sealing, and leakage classes are as defined in SMACNA - "HVAC Duct Construction Standards - Metal and Flexible":

SHEET METAL DUCT CONSTRUCTION SCHEDULE

System	Duct Geometry	Material	Pressure Class (in w.g.)	Sealing Class	Leakage Class	Press. Test Req'd
(System Type 1) Air Handling Unit Discharge to Terminal Box **(AHU-1 thru AHU-5)**	RECT	GSW	+10"	A	3	Y
(System Type 2) Return Ductwork (**RF-1 thru RF-5)**	RECT	GSW	-3"	A	6	Y
(System Type 3) Supply Ductwork for Packaged Rooftop Units, & Unit Heaters	RECT	GSW	+2"	C	24	N
(System Type 4) Return Ductwork for Packaged Rooftop Units & Unit Heaters	RECT	GSW	-2"	C	24	N
(System Type 5) Supply Ductwork Downstream of Terminal Boxes to Diffusers	RECT	GSW	+2"	B	12	N
(System Type 6) General Exhaust (Includes General Storage Areas, Toilet Rooms without Showers, and Soiled Utility Rooms)	RECT	GSW	-3	A	6	Y
(System Type 7) Exhaust from Shower Rooms (Duct Shall be aluminum until Shower	RECT	ASW	-3	A	6	Y

System	Duct Geometry	Material	Pressure Class (in w.g.)	Sealing Class	Leakage Class	Press. Test Req'd
Room exhaust is mixed by 50% with general exhaust.)						
(System Type 8) Supply Ductwork Downstream of Duct Mounted Humidifiers	RECT	ASW	+2"	A	6	N
(System Type 9) Isolation Room Exhaust	RECT	GSW	-3	A	6	Y
(System Type 10) Isolation Room Exhaust-welded fan discharge duct	RECT	GSW	+3	A	6	Y

1.23.2 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 (3.7 m) 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 (300 mm), 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 (25 mm), 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 smoke-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. Install all duct mounted smoke detectors, and other devices furnished by the Division 16 for mounting in the ductwork or air handling equipment.

M. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

N. 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 (38 mm).

O. 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 15 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 7 Section "Through-Penetration Firestop Systems."

P. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Refer to SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems".

Q. All pre-fabricated duct sections shall be cleaned prior to storage on the site and be provided with protective covering on all openings to maintain the interior of the ductwork clean and free of dust and other materials prior to installation. Field-assembled duct sections shall be cleaned during assembly and similarly protected until installation.

1. Any ductwork that is installed without complying with the protective coating requirement, will require the entire duct system to be cleaned in accordance with item 3.7 of this specification section, and NADCA (National Air Duct Cleaners Association) Standard – "Cleaning of Non-Porous Air Conveyance System Components" at no additional expense to the Owner.

R. Paint interiors of metal ducts, that do not have duct liner, for 24 inches (600 mm) upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer.

3.3 SEAM AND JOINT SEALING

A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.

1. For pressure classes lower than 2-inch wg (500 Pa), seal transverse joints.

B. Seal ducts before external insulation is applied.

3.4 HANGING AND SUPPORTING

A. Support horizontal ducts within 24 inches (600 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

B. Support vertical ducts at maximum intervals of 16 feet (5 m) and at each floor.

C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

D. Install concrete inserts before placing concrete.

E. 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 (100 mm) thick.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Division 15 Section "Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 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 leakage class requirements indicated in "Sheet Metal Duct Construction Schedule" in Part 3 of his Section.
4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

1.73.7 CLEANING NEW SYSTEMS

A. New duct system cleaning shall only be required as outlined in item 3.2.Q.1 of this specification section.

A.B. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.

B.C. Use service openings, as required, for physical and mechanical entry and for inspection.

1. Create other openings to comply with duct standards.
2. Disconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling sections to gain access during the cleaning process.

C.D. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.

D.E. Clean the following metal duct systems by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.

E.F. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

F.G. Cleanliness Verification:

1. Visually inspect metal ducts for contaminants.
2. Where contaminants are discovered, re-clean and reinspect ducts.

3.8CLEANING EXISTING SYSTEMS

A.Use service openings, as required, for physical and mechanical entry and for inspection.

1.Use existing service openings where possible.
2.Create other openings to comply with duct standards.
3.Disconnect flexible ducts as needed for cleaning and inspection.
4.Reseal rigid fiberglass duct systems according to NAIMA recommended practices.
5.Remove and reinstall ceiling sections to gain access during the cleaning process.

B.Mark position of dampers and air-directional mechanical devices before cleaning, and restore to their marked position on completion.

C.Particulate Collection and Odor Control:

1.When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron size (or larger) particles.
2.When venting vacuuming system to the outside, use filtration to contain debris removed from HVAC system, and locate exhaust down wind and away from air intakes and other points of entry into building.

D.Clean the following metal duct systems by removing surface contaminants and deposits:

1.Air outlets and inlets (registers, grilles, and diffusers).
2.Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3.Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4.Coils and related components.
5.Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
6.Supply-air ducts, dampers, actuators, and turning vanes.
7.Dedicated exhaust and ventilation components and makeup air systems.

E.Mechanical Cleaning Methodology:

1.Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2.Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3.Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4.Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5.Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6.Provide operative drainage system for washdown procedures.
7.Biocidal Agents and Coatings: Apply biocidal agents if fungus is present. Apply biocidal agents according to manufacturer's written instructions after removal of surface deposits and debris.

F.Cleanliness Verification:

1.Verify cleanliness after mechanical cleaning and before application of treatment, including biocidal agents and protective coatings.
2.Visually inspect metal ducts for contaminants.
3.Where contaminants are discovered, re-clean and reinspect ducts.

G.Gravimetric Analysis: At discretion and expense of Owner, sections of metal duct system, chosen randomly by Owner, may be tested for cleanliness according to NADCA vacuum test gravimetric analysis.

1.If analysis determines that levels of debris are equal to or lower than suitable levels, system shall have passed cleanliness verification.
2.If analysis determines that levels of debris exceed suitable levels, system cleanliness verification will have failed and metal duct system shall be re-cleaned and re-verified.

END OF SECTION 15815

SECTION 15820 - DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Pressure relief/Intake dampers:
2. Volume dampers.
3. Motorized control dampers.
4. Fire dampers.
5. Smoke dampers.
6. Sound attenuators.
7. Turning vanes.
8. Duct-mounting access doors.
9. Flexible connectors.
10. Flexible ducts.
11. Duct accessory hardware.

B. Related Sections include the following:

1. Division 13 Section "Fire Alarm" for duct-mounting fire and smoke detectors.
2. Division 15 Section "HVAC Instrumentation and Controls" for electric and pneumatic damper actuators.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Pressure Relief/Intake Dampers:

a. Provide product data indicating the damper construction.
b. Include a schedule indicating the damper size, model number, and location of all pressure relief/intake dampers provided on the project. The schedule shall include the following data based on AMCA Publication 500 testing:
1) Pressure drop.
2) Leakage rate.

3) Maximum pressure rating.
4) Maximum velocity.

2. Volume dampers.

3. Motorized control dampers.

4. Fire Dampers:

   a. Provide product data indicating the damper construction and applicable listing and labeling requirements.
   b. Include a schedule indicating the damper size, model number, and location of all fire dampers provided on the project. The schedule shall include the following data based on AMCA Publication 500 testing:
      1) Pressure drop.
      2) Leakage rate.
      3) Maximum pressure rating.
      4) Maximum velocity rating.

5. Smoke dampers.

6. Sound Attenuators:

   a. Provide product data indicating the sound attenuator construction.
   b. Include a schedule indicating the sound attenuator size (dimensions), weights, location, airflow, connection sizes, air system served, and model number of all sound attenuators provided on the project. The schedule shall include certified test data based on ASTM E477 tests performed in a NVLAP accredited laboratory for each scheduled sound attenuator. The certified data shall include the following for each sound attenuator:
      1) Dynamic insertion loss (forward or reverse flow to match air system requirements).
      2) Generated noise (forward or reverse flow to match air system requirements).
      3) Pressure drop (forward or reverse flow to match air system requirements).

7. Turning vanes.

8. Access Doors:

   a. Include a schedule indicating access door type, duct system application, access door size, number of latches, and accessories. Schedule shall indicate the type of access door coordinated with the schedules listed in Part 3 of these specifications.
   b. Provide product data indicating the access door construction for each type of access door, clearly indicate access door construction and access door type.

9. Flexible Connectors:

   a. Provide product data indicating the flexible connector construction.

b. Include a schedule indicating the type of flexible connector to be used on each system.

10. Flexible ducts.

a. Provide product data indicating the flexible connector construction.
b. Include a schedule indicating the type of flexible connector to be used on each system.

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. Manual-volume damper installations.
3. Motorized-control damper installations.
4. Fire-damper, smoke-damper, and combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.
5. 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.

1.4 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."

1.5 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. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

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.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 (Z275) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless Steel: ASTM A 480/A 480M.

D. Aluminum Sheets: ASTM B 209 (ASTM B 209M), 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 (ASTM B 221M), 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 (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.2 PRESSURE RELIEF/INTAKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide pressure relief/intake dampers by one of the following:

1. Vent Products Co., Inc. - Model 3100.
2. Ruskin Manufacturing - Model CBD2.
3. American Warming and Ventilating - Model PR-10.

B. Pressure relief/intake dampers shall be suitable for horizontal or vertical installations. Dampers shall be designed for 1,500 feet per minute air velocity, designed to operate at a temperature of 150°F, and designed to operate at a static pressure differential of 2" water gage. Damper pressure drop and leakage shall be tested in accordance with AMCA Publication 500 testing. Damper shall have a mill finish.

C. Pressure relief damper frame material shall match the mating duct system or equipment as follows:

1. Where pressure relief/intake damper connects with galvanized duct, louver, or equipment, frame shall be 14 gage, galvanized, sheet steel or 0.080-inch thick extruded or pressed formed aluminum. Provide mounting flange with bolt holes where required to connect with equipment or sheetmetal.
2. Where pressure relief/intake damper connects with aluminum duct, louver, or equipment, frame shall be 0.080-inch thick extruded or press formed aluminum. Provide mounting flange where required to connect with equipment or sheetmetal.

D. Pressure relief/intake damper blade material shall be as follows:

1. Where pressure relief/intake damper connects with galvanized duct or equipment, blade shall be 16 gage, galvanized, sheet steel, with "V" formed reinforcement or 0.063-inch

thick, extruded aluminum, airfoil shaped. The blade width shall be a maximum of 8 inches. Provide blade edge seals of either neoprene or silicon rubber.

2. Where pressure relief/intake damper connects with aluminum duct or equipment, blade shall be 0.063-inch thick, extruded aluminum, with "V" formed reinforcement or the blade shall be airfoil shaped. The blade width shall be a maximum of 8 inches for airfoil shaped blades and a maximum of 4 inches for "V" formed reinforced blades shall be 4 inches. . Provide blade edge seals of either neoprene or silicon rubber.

E. Pressure relief/intake damper axles shall be ½" minimum diameter cadmium plated steel.

F. Pressure relief/intake damper shall have ball bearings or synthetic (nylon) bearings pressed into the damper frame.

G. Pressure relief/intake damper linkage shall consist of plated steel brackets secured to damper blades, brass pivots to allow smooth operation of the linkage bar, and linkage bar consisting of a 5/16" diameter plated steel rod or 3/16" x 3/4" plated steel bar. Provide linkage tie bar for every 36 inches of damper width.

H. Pressure relief/intake damper shall be provided with an adjustable counter balance assembly secured to a damper blade axle. Provide a counterbalance assembly for every five damper blades.

2.3 MANUAL VOLUME DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide manual volume dampers by one of the following:

1. Manual Volume Dampers **(Type VD1)**:

   a. Ruskin Manufacturing - Model MD-35 (Single Blade).
   b. Vent Products Co., Inc. - Model 5101.
   c. American Warming and Ventilating - Model VC-8.
   d. Air Balance, Inc. – Model AC-111.
   e. Greenheck – Model MBD-10.

2. Manual Volume Dampers **(Type VD2)**:

   a. Ruskin Manufacturing - Model MDRS-25.
   b. Vent Products Co., Inc. - Model 5321.
   c. American Warming and Ventilating - Model VC-9.
   d. Air Balance, Inc. – Model AC-112.
   e. Greenheck – Model MBDR-50.

3. Manual Volume Dampers **(Type VD3)**:

   a. Ruskin Manufacturing – Model MD-35/OB.
   b. Vent Products Co., Inc. – Model 5103.
   c. American Warming and Ventilating – Model VC-21.

d. Air Balance, Inc. – Model AC-2.
e. Greenheck – Model MBD-15.

B. General: All manual volume dampers provided on the Project shall be constructed in accordance with the following:

1. Refer to Part 3 of this Section for the application of manual volume dampers required for each air delivery system.
2. Manual volume damper blade and frame material shall match the mating duct material. Refer to Division 15 Section "Metal Ducts" and the Drawings for duct systems requiring stainless steel or aluminum construction.
3. Manual volume damper shall be designed for damper components and duct connections to seal duct consistent with pressure class. Refer to Division 15 Section "Metal Ducts" for sealing requirements of duct systems.

C. Manual Volume Dampers (Type VD1): Factory fabricated, single blade, manual volume damper, designed for installation in rectangular, low velocity ductwork, designed for installation in either the horizontal or vertical orientation.

1. Frame:
   a. 16 gage galvanized steel hat channel.
   b. Provide 0.10 inch thick aluminum hat channel frame for manual volume dampers installed in aluminum ductwork.
2. Blades:
   a. Roll-formed, 18 gage galvanized steel.
   b. Provide roll-formed, 0.10 inch thick aluminum blade for manual volume dampers installed in aluminum ductwork.
3. Blade Axles:
   a. ½" diameter square or hex plated steel.
   b. ½" diameter square or hex Type 316 stainless steel axles for manual volume dampers installed in aluminum ductwork.
4. Bearings: Nylon, molded synthetic, or self-lubricating porous bronze.
5. Finish: Mill.
6. Performance: Designed for maximum pressure differential of 1" s.p., maximum temperature of 150 deg F, and maximum system velocity of 1,500 feet per minute.
7. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch-(2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting. Refer to Division Section "Duct Insulation" for ductwork requiring insulation.

D. Manual Volume Dampers (Type VD2): Factory fabricated, single blade, manual volume damper, designed for installation in round, low velocity ductwork, designed for installation in either the horizontal or vertical orientation.

1. Frame:
   a. 16 gage galvanized steel. Provide reinforcing beads on dampers over 18" in diameter.

b. Provide 0.10 inch thick aluminum frame for manual volume dampers installed in aluminum ductwork.

2. Blades:
   a. Roll-formed, 20 gage galvanized steel.
   b. Provide roll-formed, 0.630 inch thick aluminum blade for manual volume dampers installed in aluminum ductwork.
3. Blade Axles:
   a. 3/8" diameter square or hex plated steel.
   b. 3/8" diameter square or hex Type 316 stainless steel axles for manual volume dampers installed in aluminum ductwork.
4. Bearings: Nylon, molded synthetic, or self-lubricating porous bronze.
5. Finish: Mill.
6. Performance: Designed for maximum pressure differential of 1" s.p., maximum temperature of 150 deg F, and maximum system velocity of 1,500 feet per minute.
7. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch-(2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting. Refer to Division Section "Duct Insulation" for ductwork requiring insulation.

E. Manual Volume Dampers (Type VD3): Factory fabricated, multiple blade, opposed blade, manual volume damper, designed for installation in rectangular, low velocity ductwork, designed for installation in either the horizontal or vertical orientation.

1. Frame:
   a. 16 gage galvanized steel hat channel with mitered and welded corners.
   b. Provide 0.10 inch thick aluminum hat channel frame for manual volume dampers installed in aluminum ductwork.
2. Blades:
   a. Roll-formed, 18 gage galvanized steel, 8-inch maximum blade width.
   b. Provide roll-formed, 0.10 inch thick aluminum blade for manual volume dampers installed in aluminum ductwork, 8-inch maximum blade width.
3. Blade Axles:
   a. ½" diameter square or hex plated steel.
   b. ½" diameter square or hex Type 316 stainless steel axles for manual volume dampers installed in aluminum ductwork.
4. Control Rod:
   a. ½" diameter plated steel or 3/8" square plated steel. Control rod located out of the airstream.
   b. ½" diameter or 3/8" square Type 316 stainless steel control rod for manual volume dampers installed in aluminum ductwork. Control rod located out of the airstream.
5. Bearings: Nylon, molded synthetic, or self-lubricating porous bronze.
6. Finish: Mill.
7. Performance: Designed for maximum pressure differential of 2" s.p. for 48", maximum temperature of 150 deg F, and maximum system velocity of 2,000 feet per minute.
8. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch-(2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated

duct mounting. Refer to Division Section "Duct Insulation" for ductwork requiring insulation.

9. Jackshaft: 1-inch- (25-mm-) diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
   a. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.

2.4 MOTORIZED CONTROL DAMPERS

A. Manufacturers:

1. Ruskin Manufacturing.
2. Vent Products Co., Inc.
3. American Warming and Ventilating.
4. Air Balance, Inc.
5. Greenheck.

B. General Description: AMCA-rated, parallel or opposed-blade design; as indicated on the Drawings. Minimum of 0.1084-inch- (2.8-mm-) thick, galvanized-steel frames with holes for duct mounting; minimum of 0.0635-inch- (1.61-mm-) thick, galvanized-steel damper blades with maximum blade width of 8 inches (203 mm).

1. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
3. Provide parallel- or opposed-blade design with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm per sq. ft. (51 L/s per sq. m) of damper area, at differential pressure of 4-inch wg (995 Pa) when damper is being held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

2.5 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide fire dampers by one of the following:

1. Fire Dampers **(Type FD1)**:

   a. Air Balance Inc., a Division of Mestek, Inc. - Model D19B/Style B.
   b. Ruskin Manufacturing - Model DIBD2/Style B.
   c. Greenheck- Model DFD-150/Style B.
   d. CESCO Products- Model D75-B/Style B.

2. Fire Dampers **(Type FD2)**:

   a. Air Balance Inc., a Division of Mestek, Inc. - Model D19C/Style C.
   b. Ruskin Manufacturing - Model DIBD2/Style C.
   c. Greenheck - Model DFD-150/Style C.
   d. CESCO Products- Model D75-C/Style C.

B. General: All fire dampers provided on the Project shall be constructed in accordance with the following:

   1. Refer to Part 3 of this Section for the application of fire dampers required for each air delivery system.
   2. Fire dampers shall be constructed, tested, and labeled in accordance with UL-555 Standard for Fire Dampers. Fire dampers shall be rated and designed for use in dynamic systems.
   3. Fire dampers shall have a label affixed to indicate airflow direction, maximum rated velocity through the open damper, and the maximum differential pressure across the closed damper.
   4. Provide multiple section fire dampers as required to meet the opening size and the velocity and pressure requirements of the system.
   5. Fire damper blade and frame material shall match the mating duct material. Refer to Division 15 Section "Metal Ducts" and the Drawings for duct systems requiring stainless steel or aluminum construction.
   6. Fire Rating: One and one-half hours.

C. Type FD1: Fire Damper Frame.
   1. Fire dampers installed in low pressure duct systems (positive or negative 2" water gage and less, as indicated in Division 15 Section "Metal Ducts") shall be SMACNA Type B with blades out of air-stream.

      a. Provide fire dampers fabricated with roll-formed, 22-gauge (0.034-inch) thick galvanized steel; with mitered and interlocking corners for fire dampers that are installed in galvanized ductwork.
      b. Provide fire dampers fabricated with roll-formed, 22-gauge (0.034-inch) thick, type 316, stainless steel; with mitered and interlocking corners for fire dampers that are installed in aluminum or stainless steel ductwork.

D. Type FD2: Fire Damper Frame.

   1. Fire dampers installed in high pressure duct systems (positive or negative greater than 2" water gage, as indicated in Division 15 Section "Metal Ducts") shall be SMACNA Type C with blades and frame out of air-stream.

      a. Provide fire dampers fabricated with roll-formed, 20-gauge (0.040-inch) thick galvanized steel; with mitered and interlocking corners for fire dampers that are installed in galvanized ductwork.

b. Provide fire dampers fabricated with roll-formed, 20-gauge (0.040-inch) thick, type 316, stainless steel; with mitered and interlocking corners for fire dampers that are installed in aluminum or stainless steel ductwork.

E. Type FD1 and Type FD2 Fire Damper Mounting Sleeves: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: Fire damper mounting sleeve thickness shall be in accordance with SMACNA - "Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems" - Table 2-2 - "Recommended Minimum Sleeve Thickness for Fire Dampers".
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.

F. Type FD1 and Type FD2 Fire Damper Mounting Orientation: Vertical or horizontal as indicated on the Drawings.

G. Type FD1 and Type FD2 Fire Damper Blades:

1. Provide roll-formed, interlocking, curtain type, 22 gauge (0.034-inch) thick, galvanized, sheet steel blades, for fire dampers that are installed in galvanized ductwork.
2. Provide roll-formed, interlocking, curtain type, 22 gauge (0.034-inch) thick, type 316 stainless steel blades, for fire dampers that are installed in aluminum or stainless steel ductwork.

H. Type FD1 and Type FD2 Fire Damper Blade Lock and Negator Spring: Provide a blade lock and stainless-steel negator closure spring on horizontal and vertical mounted fire dampers.

I. Type FD1 and Type FD2 Fire Damper Fusible Links: Replaceable, 212 deg F (100 deg C) rated.

J. Type FD1 and Type FD2 Fire Damper Mullions: Provide mullions to subdivide openings required to have fire dampers that are larger than the maximum multiple damper allowable. Mullions shall be 16 gauge (0.064-inch) thick galvanized steel.

2.6 SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide smoke dampers by one of the following:

1. Smoke Dampers **(Type SD1)**:

a. PREFCO Products Inc. - Model 5150/5151-Class I.
b. Ruskin Manufacturing - Model SD60 or SD50.
c. Nailor Industries Inc. - Model 1260-Class I.
d. Air Balance Inc. - Model S1Y-350.

2. Smoke Dampers **(Type SD2)**

   a. PREFCO Products Inc. - Model 5150/5151-Class II.
   b. Ruskin Manufacturing - Model SD60-II or SD50-II.
   c. Nailor Industries Inc. - Model 1260-Class II.
   d. Air Balance Inc. - Model S2Y-350.

B. General: All smoke dampers provided on the Project shall be constructed in accordance with the following:

1. Provide factory-fabricated smoke dampers with geometry, size, capacity, pressure drop, and performance characteristics as indicated on the Drawings. All smoke dampers provided on the project shall be of the same manufacturer.
2. Refer to Part 3 of this Section for the application of smoke dampers required for each air delivery system.
3. Each smoke damper shall be classified by UL as a Leakage Rated Damper for use in smoke control systems in accordance with UL 555S and bear a UL label attesting to same.
4. Each combination fire and smoke damper shall be classified by UL as a Leakage Rated Damper for use in smoke control systems in accordance with UL 555S and bear a UL label attesting to same. In addition, combination fire and smoke dampers shall be labeled for one-and-one-half-hour rating to UL 555 and bear a UL label attesting to same.
5. Smoke dampers shall have vertical or horizontal mounting orientation as indicated on the Drawings.
6. Smoke damper blade and frame material shall match the mating duct material.
7. Smoke damper and combination fire/smoke damper actuators shall be outside the airstream
8. Smoke damper and actuator shall be factory supplied as a single entity with all UL555 and UL555S qualifications for matched damper and actuator assembly.
9. The smoke dampers and combination fire/smoke dampers shall be completely compatible with the building fire alarm system and shall interface for alarm.

C. Type SD1 Smoke Damper.

1. Damper shall be classified by U.L. as a Leakage Rated Damper-Class I (4.0 CFM/sq. ft. at 1.0" w.g.)

2. Damper shall be capable of operating (open and close) with the air delivery system operating at total pressures up to 4" w.g. in the closed position and 4,000 feet per minute in the open position.
3. Damper and actuator shall be qualified under UL555S to an elevated temperature of 350°F.
4. Damper frame shall be constructed as follows:

   a. Smoke dampers installed in galvanized steel ductwork shall have frames constructed of 16-gauge (0.064 inch thick) galvanized steel.

b. Smoke dampers installed in stainless steel or aluminum ductwork shall have frames constructed of 16-gauge (0.064 inch thick) stainless steel.

5. Damper blades shall be constructed as follows:

a. Smoke dampers installed in galvanized steel ductwork shall be 16-gauge (0.064 inch thick) galvanized steel.

b. Smoke dampers installed in stainless steel or aluminum ductwork shall be 16-gauge (0.064 inch thick) stainless steel.

D. Type SD2: Smoke Damper.

1. Damper shall be classified by U.L. as a Leakage Rated Damper-Class II (10.0 CFM/sq. ft. at 1.0" w.g.)
2. Damper shall be capable of operating (open and close) with the air delivery system operating at total pressures up to 4" w.g. in the closed position and 2,000 feet per minute in the open position.
3. Damper and actuator shall be qualified under UL555S to an elevated temperature of 350°F.

E. Damper Actuator: Pneumatic actuator factory installed. Damper blades shall be held open by actuator and close when air is interrupted. Air shall be interrupted when an area smoke detector triggers the damper's e-p relay to cut and bleed the air supply from the damper.

2.7 SOUND ATTENUATORS

A. Manufacturers: Subject to compliance with requirements, provide sound attenuators by one of the following:

1. Vibro-Acoustics.
2. IAC-Industrial Acoustics Company.
3. United McGill Corporation.

B. General: Factory-fabricated and -tested, sound attenuator with geometry, size, capacity, and acoustic performance characteristics as indicated on the Drawings. All sound attenuators provided on the Project shall be of the same manufacturer.

C. All sound attenuators provided on the project shall be constructed in accordance with the following:

1. Sound attenuators shall be constructed in accordance with ASHRAE and SMACNA standard for the pressure and velocity classification indicated in Division 15 Section "Metal Ducts" for the air distribution system in which the sound attenuator is installed. Material gages indicated in this Section shall be increased as required to meet the system velocity and pressure classifications and shall, as a minimum, not fail structurally when subjected to a differential pressure of 8-inch wg static pressure.

2. Construction of sound attenuators shall match the mating duct material. Refer to Division 15 Section "Metal Ducts" and the Drawings for required duct system material.
3. 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.
   a.
4. Where casings are indicated to be galvanized sheet metal, they shall conform to ASTM A 653/A 653M, G90 (Z275).
5. Sheet metal perforations shall be 1/8-inch (3-mm) diameter for inner casing and baffle sheet metal.
6. All sound attenuator casings shall be lockformed and sealed to provide a leakage rate in accordance with the system in which the sound attenuator is installed.
7. All perforated metal shall be adequately stiffened to in sure flatness and form. All spot welds shall be painted.
8. All sound attenuator inlet and outlet connection dimensions must be equal to the duct sizes indicated on the Drawings. Duct transitions to inlet or outlet of the sound attenuators are not acceptable unless specifically indicated on the Drawings.
9. Fabricate sound attenuators to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Provide cross or trapeze angles for rigid suspension as required to meet system requirements. Do not use nuts, bolts, or sheet metal screws for unit assemblies.
10. Sound attenuator pressure drops shall not exceed those indicated on the Drawings. Sound attenuator pressure drop measurements shall be made in accordance with the ASTM E-477 test standard. Tests shall be conducted and reported on the identical units for which acoustical data is presented.

D. Rectangular sound attenuators with and without acoustic media shall be constructed as follows:

1. Provide rectangular sound attenuator of galvanized steel construction for sound attenuators installed in galvanized ductwork. Fabricate casings with a minimum of 22-gauge (0.034-inch thick), solid sheet metal for outer casing and 26-gauge (0.022-inch thick), perforated sheet metal for inner casing.
2. Provide rectangular sound attenuator of aluminum construction for sound attenuators installed in aluminum ductwork. Refer to Division 15 Section "Metal Ducts" and the Drawings for duct systems required to be aluminum. Fabricate casings with a minimum of 0.043-inch thick solid sheet aluminum for the outer casing and 0.027-inch thick perforated sheet aluminum for the inner casing.
3. Provide rectangular sound attenuator of stainless steel construction for sound attenuators installed in stainless steel ductwork. Refer to Division 15 Section "Metal Ducts" and the Drawings for duct systems required to be stainless steel. Fabricate casings with a minimum of 22-gauge (0.034-inch thick), solid stainless steel (Type 316L) for outer casing and 26-gauge (0.022-inch thick), perforated stainless steel (Type 316L) for inner casing.

E. Round or Circular Sound Attenuators with Acoustic Media: Casings with sheet metal thicknesses for diameters listed below:

1. Less than 30 Inches: 20-gauge (0.040 inch thick).
2. 31 through 54 Inches: 18-gauge (0.052 inch thick).

3. Over 54 Inches: 16-gauge (0.064 inch thick).
4. Casing seams and joints shall be lockformed and sealed or stitch welded and sealed.
5. Interior Partitions and Baffles: At least 22-gauge (0.034-inch thick).
6.

F. Elbow sound attenuators with and without acoustic media shall be constructed as follows:

1. Provide elbow sound attenuator of galvanized steel construction for sound attenuators installed in galvanized ductwork. Fabricate casings with a minimum of 18-gauge (0.052-inch thick), solid sheet metal for outer casing and 22-gauge (0.034-inch thick), perforated sheet metal for inner casing. All acoustical splitters shall be internally radiused and aerodynamically designed for efficient turning of the air. Half and full splitters are required as necessary to achieve the insertion loss indicated on the Drawings. All elbow attenuators with the longest dimension of the turning cross section greater than 48" shall have at least two half splitters and one full splitter.
2. Provide elbow sound attenuator of aluminum construction for sound attenuators installed in aluminum ductwork. Refer to Division 15 Section "Metal Ducts" and the Drawings for duct systems required to be aluminum. Fabricate casings with a minimum of 0.067-inch thick solid sheet aluminum for the outer casing and 0.043-inch thick perforated sheet aluminum for the inner casing.
3. Provide elbow sound attenuator of stainless steel construction for sound attenuators installed in stainless steel ductwork. Refer to Division 15 Section "Metal Ducts" and the Drawings for duct systems required to be stainless steel. Fabricate casings with a minimum of 18-gauge (0.052-inch thick), solid stainless steel (Type 316L) for outer casing and 22-gauge (0.034-inch thick), perforated stainless steel (Type 316L) for inner casing.

G. Transitional sound attenuators with and without acoustic media shall be constructed as follows:

1. Provide transitional sound attenuator of galvanized steel construction for sound attenuators installed in galvanized ductwork. Fabricate casings with a minimum of 22-gauge (0.034-inch thick), solid sheet metal for outer casing and 22-gauge (0.034-inch thick), perforated sheet metal for inner casing. Transitioning shall occur internal to the attenuator such that the height of the gap or air passage is uniformly changing with the length of the splitters.
2. Provide transitional sound attenuator of aluminum construction for sound attenuators installed in aluminum ductwork. Refer to Division 15 Section "Metal Ducts" and the Drawings for duct systems required to be aluminum. Fabricate casings with a minimum of 0.043-inch thick solid sheet aluminum for the outer casing and 0.043-inch thick perforated sheet aluminum for the inner casing.
3. Provide transitional sound attenuator of stainless steel construction for sound attenuators installed in stainless steel ductwork. Refer to Division 15 Section "Metal Ducts" and the Drawings for duct systems required to be stainless steel. Fabricate casings with a minimum of 22-gauge (0.034-inch thick), solid stainless steel (Type 316L) for outer casing and 22-gauge (0.034-inch thick), perforated stainless steel (Type 316L) for inner casing.

H. Dissapative type sound attenuators shall have acoustic quality media, shot-free glass fiber insulation with long, resilient fibers bonded with a thermosetting resin. Glass fiber density and compression shall be as required to insure conformance with laboratory test data. Glass fiber

shall be packed with a minimum of 15 percent compression during attenuator assembly. Media shall be bacteria and fungus resistant, resilient such that it will not crumble or break, and shall conform to irregular surfaces. Media shall not cause or accelerate corrosion of aluminum or steel.

1. Unless noted otherwise the acoustic media shall be completely wrapped with Tedlar film to prevent shedding, erosion, and impregnation of the glass fiber. The wrapped acoustic media shall be separated from perforated metal by a factory installed ½" thick acoustically transparent spacer. The spacer shall be flame retardant and erosion resistant.
2. Sound attenuator materials, including glass fiber, sealers, Tedlar film, and acoustic spacer shall have maximum combustion ratings of 25 for flamespread classification and 50 for smoke developed rating when tested in accordance with ASTM E84.

I. All non-media type sound attenuators shall not contain absorptive media of any kind. Attenuation shall be achieved with controlled impedance membranes and broadly tuned resonators.

J. Options and Accessories:

1. Provide access doors in all sound attenuators where indicated on the Drawings or as required to permit fire, smoke, or automatic control damper access. Access doors shall be provided as an integral part of the sound attenuator and shall be factory installed. Where high transmission loss walls are provided as an option, the access door shall not reduce the effectiveness of the sound attenuator walls.
2. Provide high transmission loss casings where indicated on the Drawings. The high transmission loss casings shall be externally applied to the sound attenuator and shall be factory sealed to the exterior casing. The high transmission loss walls shall consist of media, airspace, mass, and outer protective metal skin. The thickness of the outer skin shall be as indicated on the Drawings or as required to obtain the specified room noise criteria.
3. Provide flanges or transverse connections to mate with duct system on all sound attenuators installed in ductwork. Coordinate with Division °15 Section "Metal Ducts".
4. Provide mounting brackets on sound attenuators to allow for suspension of the unit from the structure above.
5. Provide support legs on sound attenuators to allow for floor mounting of the unit.

K. Source Quality Control: Perform the following factory tests:

1. Acoustic Performance: Test according to ASTM E 477, with airflow in both directions through silencer.
2. Record acoustic ratings, including dynamic insertion loss and self-noise power levels, for both forward flow (air and noise in same direction) and reverse flow (air and noise in opposite directions) in accordance with the Projects' air distribution system requirements. Perform tests with a minimum airflow velocity of at least 2000-fpm (10-m/s) face velocity or the velocity scheduled on the Drawings, whichever is higher.
3. Leak Test: Test sound attenuators for air-tightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater. Testing of sound attenuators shall not be required on sound attenuators installed in systems classified as 2-inch wg (positive or negative) pressure class or lower.

2.8 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide acoustic turning vanes by one of the following:

   a. Ductmate Industries, Inc.
   b. Duro Dyne Corp.
   c. METALAIRE, Inc.
   d. Ward Industries, Inc.

B. Manufactured Turning Vanes: Fabricate 1-1/2-inch- (38-mm-) wide, double-vane, curved blades of set 3/4 inch (19 mm) o.c.; support with bars perpendicular to blades set 2 inches (50 mm) o.c.; and set into vane runners suitable for duct mounting.

   1. Construction of turning vanes shall match the mating duct material. Refer to Division 15 Section "Metal Ducts" and the Drawings for required duct system material.

C. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

D. Contractors Option: In lieu of providing factory manufactured turning vanes, contractor may fabricate turning vanes to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

2.9 DUCT-MOUNTING ACCESS DOORS

A. All access doors provided on the project shall be constructed in accordance with the following:

   1. Fabricate doors and panels airtight and suitable for duct pressure class.
   2. Unhinged access doors shall be chained to the access door frame to prevent loss of the door. Chain length shall be a minimum of 6" in length.
   3. Insulation provided in access doors shall have a maximum combustion ratings of 25 for flame-spread classification and 50 for smoke developed rating when tested in accordance with ASTM E84.
   4. Access door and frame material shall be the same as the attached duct material. Refer to Division 15 Section "Metal Ducts" and the Drawings for duct system construction material required.
   5. Access door sizes and access door type for each duct system are listed in the access door schedules in Part 3 of this specification.

B. Type A and Type B:

   1. Manufacturers: Subject to compliance with requirements, provide Type A duct mounted access doors by one of the following:

      a. Ruskin Manufacturing - Model ADH-12.
      b. Nailor Industries Inc. - Model 08SH (Uninsulated).

c. Kees Inc. - Model ADH-S (Uninsulated).
d. Greenheck - Model HAD-10 (Uninsulated).
e. Air Balance Inc. - Model FSA-500.

2. Manufacturers: Subject to compliance with requirements, provide Type B duct mounted access doors by one of the following:

a. Ruskin Manufacturing - Model ADH-22.
b. Nailor Industries Inc. - Model 08SH.
c. Kees Inc. - Model ADH-D.
d. Greenheck - Model HAD-10.
e. Air Balance Inc. - Model FSA-100.

3. Access door frames for Type A and Type B access doors shall be constructed as follows:

a. Frame shall be galvanized, sheet steel, with bend-over tabs and foam gaskets for access doors installed in galvanized ductwork. Access door frames 12" x 12" and smaller shall be minimum 24-gauge (0.028-inch thick) and access door frames 13" x 13" and larger shall be minimum 22-gauge (0.034-inch thick).
b. Provide access door frames of aluminum construction with bend-over tabs and foam gaskets for access doors installed in aluminum ductwork. Access door frames 12" x 12" and smaller shall be minimum 0.04" thick aluminum and access door frames 13" x 13" and larger shall be minimum 0.05" thick aluminum.
c. Frame shall be Type 316 stainless steel, with bend-over tabs and foam gaskets for access doors installed in stainless steel ductwork. Access door frames 12" x 12" and smaller shall be minimum 24-gauge (0.028-inch thick), Type 316 stainless steel and access door frames 13" x 13" and larger shall be minimum 22-gauge (0.034-inch thick), Type 316 stainless steel.

4. Door construction for Type A access doors shall be as follows:

a. Door shall be single-wall, 22-gauge (0.034-inch thick), galvanized, sheet metal construction for access doors installed in galvanized ductwork.
b. Door shall be single-wall, 0.05-inch thick, aluminum construction for access doors installed in aluminum ductwork.
c. Door shall be single-wall, 22-gauge (0.034-inch thick), Type 316 stainless steel construction for access doors installed in stainless steel ductwork.

5. Door construction for Type B access doors shall be as follows:

a. Door shall be double-wall, insulated, 22-gauge (0.034-inch thick), galvanized, sheet metal construction for access doors installed in galvanized ductwork. Insulation shall be 1-inck thick, fibrous-glass or polystyrene-foam board.
b. Door shall be double-wall, insulated, 0.05-inch thick, aluminum construction for access doors installed in aluminum ductwork. Insulation shall be 1-inck thick, fibrous-glass or polystyrene-foam board.
c. Door shall be double-wall, insulated, 22-gauge (0.034-inch thick), Type 316 stainless steel construction for access doors installed in stainless steel ductwork. Insulation shall be 1-inck thick, fibrous-glass or polystyrene-foam board.

6. Provide a continuous piano hinge and number of cam latches as follows:

a. Access doors smaller than 12" x 12" shall have one latch.
b. Access doors 12" x 12" and larger shall have a minimum of two latches.
c. Provide 4 cam latches in lieu of piano hinge where door swing is obstructed.

7. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.
8. Provide a single pane plexiglass window in all Type A and Type B access doors installed for the purpose of accessing fire dampers, smoke dampers, and automatic control dampers.

C. Type C:

1. Manufacturers: Subject to compliance with requirements, provide Type C duct mounted access doors by one of the following:

a. Ruskin Manufacturing - Model ADR.
b. Nailor Industries Inc. - Model 0890.
c. Semco Inc. - Model S40.

2. Door construction for Type C access doors shall be as follows:

a. Door shall be single wall, 16-gage (0.064-inch thick) galvanized steel for access doors installed in galvanized ductwork.
b. Door shall be single-wall, 0.09-inch thick, aluminum construction for access doors installed in aluminum ductwork.
c. Door shall be single wall, 16-gage (0.064-inch thick), Type 316 stainless steel for access doors installed in galvanized ductwork.

3. Provide a continuous piano hinge with a minimum of two plated steel strikes and catches.
4. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

D. Type D:

1. Manufacturers: Subject to compliance with requirements, provide Type D duct mounted access doors by one of the following:

a. Kees Inc. - Model ADH-R.
b. Ruskin Manufacturing - Model ADH-22 (with turret for connection to round duct).
c. Nailor Industries Inc. - Model 08SH (with turret for connection to round duct).

2. Door construction for Type D access doors shall be as follows:

a. Door shall be double-wall, insulated, 22-gauge (0.034-inch thick), galvanized, sheet metal construction for access doors installed in galvanized ductwork. Insulation shall be 1-inck thick, fibrous-glass or polystyrene-foam board.
b. Door shall be double-wall, insulated, 0.05-inch thick, aluminum construction for access doors installed in aluminum ductwork. Insulation shall be 1-inck thick, fibrous-glass or polystyrene-foam board.
c. Door shall be double-wall, insulated, 22-gauge (0.034-inch thick), Type 316 stainless steel construction for access doors installed in stainless steel ductwork. Insulation shall be 1-inck thick, fibrous-glass or polystyrene-foam board.

3. Provide a continuous piano hinge and number of cam latches as follows:

   a. Access doors smaller than 12" x 12" shall have one latch.
   b. Access doors 12" x 12" and larger shall have a minimum of two latches.
   c. Provide 4 cam latches in lieu of piano hinge where door swing is obstructed.

4. Access doors shall utilize a turret type design constructed with a saddle to conform to the radius of the duct and shall be constructed as follows:

   a. Access doors installed in galvanized ductwork shall have a turret constructed of minimum 20-gauge (0.040-inch thick) galvanized steel.
   b. Access doors installed in aluminum ductwork shall have a turret constructed of minimum 0.063-inch thick aluminum.
   c. Access doors installed in stainless steel ductwork shall have a turret constructed of minimum 20-gauge (0.040-inch thick), Type 316 stainless steel.

5. Seal around turret attachment to duct and door to turret with neoprene or foam rubber.
6. Provide a single pane plexi-glass window in all "Type D" access doors installed for the purpose of accessing fire dampers, smoke dampers, and automatic control dampers.

E. Type E and Type F:

1. Manufacturers: Subject to compliance with requirements, provide Type E duct mounted access doors by one of the following:

   a. Ductmate Industries Inc. - Model "The Sandwich" (Uninsulated).
   b. United McGill Corp. - Model AOBXFSDF (Uninsulated).

2. Manufacturers: Subject to compliance with requirements, provide Type F duct mounted access doors by one of the following:

   a. Ductmate Industries Inc. - Model "The Sandwich" (Insulated).
   b. United McGill Corp. - Model AOBXFSDF (Insulated).

3. Access doors shall be sandwich type construction, suitable for use in rectangular duct-work, and shall be removable, by hand without the need for tools. The access door shall be designed such that the inner plate is tightened against the outer door providing a positive airtight seal.
4. Doors for Type E and Type F access doors shall be constructed as follows:

   a. Access doors installed in galvanized ductwork shall be minimum 22-gauge (0.034-inch thick) galvanized steel outer door and inner plate. The outer door shall be connected to the inner plate by means of spring loaded carriage bolts with hand operated knobs.
   b. Access doors installed in aluminum ductwork shall be minimum 0.05-inch thick aluminum outer door and inner plate. The outer door shall be connected to the inner plate by means of spring loaded carriage bolts with hand operated knobs.
   c. Access doors installed in stainless steel ductwork shall be minimum 22-gauge (0.034-inch thick), Type 316 stainless steel outer door and inner plate. The outer door shall be connected to the inner plate by means of spring loaded carriage bolts with hand operated knobs.

5. Type F access doors shall be provided with insulation with a minimum R-value of 7.0. Insulation shall be closed cell, bonded to the inside of the outer door or shall be high-density fiberglass encapsulated between two layers of sheetmetal. The design shall be such that the inside surface of the access door shall be the only surface in contact with the air-stream.
6. Access doors shall seal tight against the duct wall with a closed cell gasket with a service temperature range of -70°F to 220°F. The gasket shall be permanently bonded to the inner door.
7. Access door shall be leak tested at 10" water gauge with no leakage.

F. Type L:

1. Manufacturers: Subject to compliance with requirements, provide Type L duct mounted access doors by one of the following:

   a. Kees Inc. - Model BO.

2. Access door shall be designed for the express intent of opening outward to prevent bursting of ductwork under excessive positive pressure.
3. Door and frame shall be constructed of 12-gauge (0.105 inch thick) galvanized steel. Door shall be provided with a continuous piano hinge and shall have a ¼" thick gasket around the entire perimeter of door.
4. Access door pressure relief mechanism shall consist of a latch body with a spring loaded laminated cam and adjustment screw. The latch shall engage a frame mounted strike with a roller pin. Access door pressure relief setting shall be adjustable from 3" to 8" water gauge.

2.10 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide flexible connectors by one of the following:

1. Ventfabrics, Inc.

   a. Ventglas model for all conventional, non-corrosive applications, used in an interior location, with temperatures below 200°F.
   b. Ventlon model for all exterior, non-corrosive applications.
   c. Ventsil model for all high temperature applications (above 200°F).
   d. Ventel model for all corrosive applications.

2. Duro Dyne National Corp., Inc.

   a. Neoprene model for all conventional, non-corrosive applications, used in an interior location, with temperatures below 200°F.
   b. Durolon model for all exterior applications.
   c. Thermafab model for all high temperature applications (above 200°F).
   d. Durolon or Neoprene model for all corrosive applications.

B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Select metal compatible with ducts.

D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

E. 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. (810 g/sq. m).
2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).

F. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz./sq. yd. (542 g/sq. m).
2. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and 185 lbf/inch (32 N/mm) in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

G. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).
2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

2.11 METAL BELLOWS LOW PRESSURE EXPANSION JOINT

A. Manufacturers: Subject to compliance with requirements, provide flexible metal bellows duct for EF-3 discharge by:

1. Hyspan Precision Products, Inc

2. Low pressure expansion joint, 2500 Series.

3. Max design pressure rating, 15 PSIG.

4. Angle flange connection.

2.112.12 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide flexible ducts by one of the following:

1. Flexmaster U.S.A., Inc.
2. Hart & Cooley, Inc.
3. McGill AirFlow Corporation.

B. Noninsulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20.3 m/s).
3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).

C. Insulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor barrier film.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20.3 m/s).
3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).

D. Flexible Duct Clamps: Nylon strap, in sizes 3 through 18 inches (75 to 450 mm) to suit duct size.

2.122.13 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 volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

D. Provide test holes at fan inlets and outlets and elsewhere as indicated.

E. Install fire and smoke dampers, with fusible links, according to manufacturer's UL-approved written instructions.

F. Install duct silencers rigidly to ducts.

G. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

H. For fans developing static pressures of 5-inch wg (1250 Pa) and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

I. Connect terminal units to supply ducts directly.

J. Connect diffusers to low pressure ducts directly or with maximum 48-inch lengths of flexible duct clamped or strapped in place. Flexible duct shall be limited to the vertical drop from branch duct to diffuser or register.

K. Install duct test holes where indicated and required for testing and balancing purposes.

3.2 INSTALLATION OF MANUAL VOLUME DAMPERS

A. 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.

3.3 INSTALLATION OF ACCESS DOORS

A. Install duct access doors for access to both sides of inline fans and duct coils, including terminal box coils. Install duct access doors downstream from automatic control dampers, fire dampers, smoke dampers, combination fire/smoke dampers, humidifiers, airflow measuring stations, and similar equipment.

1. Install duct access doors to allow access to interior of ducts for cleaning, inspecting, adjusting, and maintaining accessories and terminal units.

2. Access doors provided for inspection and cleaning shall be provided at intervals of approximately 40 feet to allow for a maximum reach of 20 feet in straight horizontal runs, upstream and downstream of each elbow and tee in supply and return duct systems.
3. Install access doors on side or bottom of duct where adequate clearance is available.

B. Label access doors according to Division 15 Section "Mechanical Identification".

3.4 ACCESS DOOR SCHEDULES

Access Doors for Rectangular Supply, Return, and Exhaust Duct Systems (Pressure Class 2" and Below)

Pressure Class	Insulated (Y/N)	Duct Geometry	Max. Duct Width or Diameter	Access Door Type	Minimum Access Door Size
2" & Less	N	Rect.	6" thru 12"	A	6" x 6"
2" & Less	N	Rect.	13" thru 20"	A	12" x 12"
2" & Less	N	Rect.	21" and Up	A	18" x 18"
2" & Less	Y	Rect.	6" thru 12"	B	6" x 6"
2" & Less	Y	Rect.	13" thru 20"	B	12" x 12"
2" & Less	Y	Rect.	21" and Up	B	18" x 18"

Access Doors for Round Supply, Return, and Exhaust Duct Systems (Pressure Class 2" and Below)

Pressure Class	Insulated (Y/N)	Duct Geometry	Max. Duct Width or Diameter	Access Door Type	Minimum Access Door Size
2" & Less	N	Round	6" thru 8"	C	8" x 5"
2" & Less	N	Round	9" thru 12"	C	11" x 8"
2" & Less	N	Round	13" thru 18"	C	16" x 12"
2" & Less	N	Round	18" and Up	C	18" x 14"
2" & Less	Y	Round	6" thru 8"	D	8" x 5"
2" & Less	Y	Round	9" thru 12"	D	11" x 8"
2" & Less	Y	Round	13" thru 18"	D	16" x 12"
2" & Less	Y	Round	18" and Up	D	18" x 14"

Access Doors for Rectangular Supply, Return, and Exhaust Duct Systems (Pressure Class 3" and Above)

Pressure Class	Insulated (Y/N)	Duct Geometry	Max. Duct Width or Diameter	Access Door Type	Minimum Access Door Size
3" & Up	N	Rect.	6" thru 12"	E	10" x 6"

Pressure Class	Insulated (Y/N)	Duct Geometry	Max. Duct Width or Diameter	Access Door Type	Minimum Access Door Size
3" & Up	N	Rect.	13" thru 20"	E	12" x 8"
3" & Up	N	Rect.	21" and Up	E	18" x 14"
3" & Up	Y	Rect.	6" thru 12"	F	10" x 6"
3" & Up	Y	Rect.	13" thru 20"	F	12" x 8"
3" & Up	Y	Rect.	21" and Up	F	18" x 14"

Positive Pressure Relief Type Access Doors
for Rectangular, Round, and Flat Oval Supply, Return, and Exhaust Duct Systems
(Single Wall - Pressure Class 3" and Above)

Pressure Class	Insulated (Y/N)	Duct Geometry	Max. Duct Width or Diameter	Access Door Type	Minimum Access Door Size
3" & Up	Y	Rect./Round/Oval	All Sizes	L	Note 1

NOTE 1: Install positive pressure relief type access doors in ductwork of pressure class 3" above downstream of all air handling unit supply ductwork mains and shall be the size indicated on the Drawings.

1.53.5 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.

C. Final positioning of manual-volume dampers is specified in Division 15 Section "Testing, Adjusting, and Balancing."

END OF SECTION 15820

SECTION 15837 - CENTRIFUGAL FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base air ratings on 130 ft elevation.

B. Operating Limits: Classify according to AMCA 99.

1.4 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 gages 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.

1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation hanger Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

D. Maintenance Data: For centrifugal fans to include in maintenance manuals specified in Division 1.

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. 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.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural steel support members.

B. Coordinate size and location of hanger rods. Hanger requirements are specified Section 15060 "HVAC Hangers And Supports."

C. Coordinate installation of equipment supports.

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. Belts: One set for each belt-driven unit.

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. Acme Engineering & Mfg. Corp.
2. Barry Blower Corp.
3. Chicago Blower Corp.
4. Cook, Loren Company.
5. Greenheck Fan Corp.

2.2 MANUFACTURED UNITS

A. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.

2.3 HOUSINGS

A. Materials and Fabrication: Formed and reinforced steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and doors or panels to allow access to internal parts and components.

1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Fabrication Class: AMCA 99, Class I
3. Horizontal Flanged Split Housing: Bolted construction.
4. Tubular Centrifugal Fans: Fabricate tubular housing from formed and reinforced steel panels with welded seams and the following:

a. Outlet guide vanes.
b. Motor and disconnect switch.
c. Spun inlet cone with flange.
d. Outlet flange.
e. Brackets suitable for horizontal.

B. Coatings: Color-match enamel.

2.4 WHEELS

A. Airfoil-Fan Wheels: Steel construction with smooth-curved inlet flange; heavy back plate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and back plate; cast-iron or cast-steel hub riveted to back plate and fastened to shaft with set screws.

B. Coatings: Color-match enamel.

2.5 SHAFTS

A. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

B. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.

C. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

2.6 BEARINGS

A. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, L_{10} of **120,000** hours.
2. Roller-Bearing Rating Life: ABMA 11, L_{10} of **120,000** hours.

B. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, L_{10} of **120,000** hours.
2. Roller-Bearing Rating Life: ABMA 11, L_{10} of **120,000** hours.

2.7 BELT DRIVES

A. Description: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor: 1.2.

B. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.

C. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.

D. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.

1. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements; 0.1046-inch-(2.7-mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

E. Motor Mount: Adjustable for belt tensioning.

2.8 ACCESSORIES

A. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.

B. Companion Flanges: Galvanized steel, for duct connections.

C. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.

2.9 MOTORS

A. Refer to Division 15 Section "Motors" for general requirements for factory-installed motors.

B. Motor Construction: NEMA MG 1, general purpose, continuous duty, high efficiency, Design B.

C. Enclosure Type: Open dripproof.

2.10 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 centrifugal fans level and plumb.

B. Support suspended units from structure using threaded steel rods and spring hangers. Vibration-control devices are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."

1. In seismic zones, restrain support units.

C. Install units with clearances for service and maintenance.

D. Label fans according to requirements specified in Division 15 Section "Mechanical Identification."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Duct Accessories." Flexible connector for the discharge of Isolation Exhaust Fan EF-3, is a metal bellows type, welded to duct and fan with a positive pressure leakage rating of 6" W.C. min.

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install access doors in ducts either side of fans for equipment service. Access panels as specified in section 15820.

D. Ground equipment.

E. 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.

3.3 FIELD QUALITY CONTROL

A. Equipment Startup Checks:

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. Verify lubrication for bearings and other moving parts.
6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

B. Starting Procedures:

1. Energize motor and adjust fan to indicated rpm.
2. Measure and record motor voltage and amperage.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Shut unit down and reconnect automatic temperature-control operators.

F. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

G. Replace fan and motor pulleys as required to achieve design airflow.

H. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

3.5 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."

4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15837

SECTION 15838 - POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. In-line centrifugal fans.
2. Propeller fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base air ratings on sea-level conditions.

B. Operating Limits: Classify according to AMCA 99.

1.4 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 gages 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.

1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Maintenance Data: For power ventilators to include in maintenance manuals specified in Division 1.

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. 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.

1.6 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.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate installation of equipment supports.

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. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. In-Line Centrifugal Fans:

   a. Cook, Loren Company.
   b. Barry Blower Div./Penn Ventilation Companies, Inc.
   c. Bayley Fans, Lau Commercial Industrial Fans/Lau Industries.
   d. Greenheck Fan Corp.
   e. Penn Ventilation Companies, Inc.

2. Aluminum Centrifugal Vent Set Fans:

   a. Cook, Loren Company.
   b. Barry Blower Div./Penn Ventilation Companies, Inc.
   c. Bayley Fans, Lau Commercial Industrial Fans/Lau Industries.
   d. Greenheck Fan Corp.
   e. Penn Ventilation Companies, Inc.

3. Propeller Fans:

   a. Cook, Loren Company.
   b. Bayley Fans, Lau Commercial Industrial Fans/Lau Industries.
   c. Greenheck Fan Corp.
   d. Penn Ventilation Companies, Inc.

2.2 IN-LINE CENTRIFUGAL FANS

A. Description: In-line, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

B. Housing: Welded and bolted construction, 14-gage steel. Integral inlet and outlet flanges.

C. Belt-Driven Units: Motor mounted on adjustable base, with sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

1. Service Factor Based on Fan Motor: 1.5.
2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
3. Motor Pulleys: Adjustable pitch. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
5. Motor Mount: Adjustable for belt tensioning.

D. Fan Wheels: Steel, non-overloading, centrifugal backward inclined, airfoil type fan wheel. Blades shall be continuously welded to the backplate and inlet shroud. Hubs shall be keyed to fan shaft. Fan wheel shal be balanced in accordance with AMCA Standard 204-96, "Balance Quality and Vibration Levels for Fans".

E. Coatings: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).Powder-baked enamel.

1. Paint must exceed 1,000 hour salt spray under ASTM B117 test method.

F. Grease-Lubricated Shaft Bearings: Ball or roller bearings with adapter mount and two-piece, cast-iron housing.

a. Ball-Bearing Rating Life: ABMA 9, L_{10} of 200,000 hours.
b. Roller-Bearing Rating Life: ABMA 11, L_{10} of 200,000 hours.

G. Shaft: Turned, ground, and polished hot-rolled steel with keyway. Selected for continuous operation at maximum rated fan speed and motor horsepower

1. Designed and sized for a critical speed of at least 125% of maximum RPM.

H. Motors: Refer to Division 15 Section "Motors" for general requirements for factory-installed motors.

1. Motor Construction: NEMA MG 1, general purpose, continuous duty, Design B. Refer to Division 15 Section "Motors" for motor efficiency requirements.
2. Enclosure Type: Open dripproof.

I. Accessories:

1. Companion Flanges: For inlet and outlet duct connections.
2. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.3 ALUMINUM CENTRIFUGAL VENT SET FANS

A. Description: Single width, single inlet, backward inclined aluminum wheel, belt driven centrifugal vent set. Fan shall be AMCA 99 Type A sparkproof construction.

B. Housing: The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The scroll wrapper and side panels shall be aluminum. The entire fan housing shall have continuously welded seams for leakproof operation. The fan housing shall be field rotatable to any one of eight discharge positions Side access inspection ports shall be provided with quick release latches for access to the motor compartment without removing the weather cover. Lifting lugs shall be provided for ease of installation. Unit shall bear an engraved aluminum nameplate.

C. Belt-Driven Units: Motor mounted on adjustable base, with sheaves, , and lubricating tubes from fan bearings extended to outside of fan housing.

1. Service Factor Based on Fan Motor: 1.5.
2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
3. Motor Pulleys: Adjustable pitch. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
5. Motor Mount: Adjustable for belt tensioning.

D. Fan Wheels: Aluminum, non-overloading, centrifugal backward inclined, flatblade type fan wheel. Blades shall be continuously welded to the backplate and inlet shroud. Hubs shall be keyed to fan shaft. Fan wheel shall be balanced in accordance with AMCA Standard 204-96, "Balance Quality and Vibration Levels for Fans".

E. Coatings: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).Powder-baked enamel.

1. Paint must exceed 1,000 hour salt spray under ASTM B117 test method.

F. Grease-Lubricated Shaft Bearings: Ball or roller bearings with adapter mount and two-piece, cast-iron housing.

a. Ball-Bearing Rating Life: ABMA 9, L_{50} of 200,000 hours.

G. Shaft: Turned, ground, and polished Type 316 Stainless Steel with keyway. Selected for continuous operation at maximum rated fan speed and motor horsepower

1. Designed and sized for a critical speed of at least 125% of maximum RPM.

H. Motors: Refer to Division 15 Section "Motors" for general requirements for factory-installed motors.

1. Motor Construction: NEMA MG 1, general purpose, continuous duty, Design B. Refer to Division 15 Section "Motors" for motor efficiency requirements.
2. Enclosure Type: Open dripproof.

I. Accessories:

1. Companion Flanges: For inlet and outlet duct connections.
2. Motor and Drive Cover (OSHA Belt Guard): Epoxy-coated steel.

2.4 PROPELLER FANS

A. Description: Belt-driven or direct-driven propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.

B. Housing: Galvanized steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.

C. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.

D. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor: 1.4.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

    a. Ball-Bearing Rating Life: ABMA 9, L_{10} of 100,000 hours.

4. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
6. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
7. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

E. Accessories:

1. Motorized Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
2. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
3. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

2.5 MOTORS

A. Refer to Division 15 Section "Motors" for general requirements for factory-installed motors.

B. Motor Construction: NEMA MG 1, general purpose, continuous duty, Design B.

C. Enclosure Type: Open dripproof.

2.6 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 suspended units from structure using threaded steel rods and spring hangers. Vibration-control devices are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."

1. In seismic zones, restrain support units.

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Division 15 Section "Mechanical Identification."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment.

D. 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.

3.3 FIELD QUALITY CONTROL

A. Equipment Startup Checks:

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. Verify lubrication for bearings and other moving parts.
6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
7. Disable automatic temperature-control operators.

B. Starting Procedures:

1. Energize motor and adjust fan to indicated rpm.
2. Measure and record motor voltage and amperage.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Shut unit down and reconnect automatic temperature-control operators.

F. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

G. Replace fan and motor pulleys as required to achieve design airflow.

H. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

3.5 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain power ventilators.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15838

SECTION 15845 - AIR TERMINALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Single-duct air terminals.

B. Related Sections include the following:

1. Division 15 Section "Duct Insulation" for external insulation of air terminals.
2. Division 15 Section "HVAC Instrumentation and Controls Systems" for control devices installed on air terminals.

1.3 DEFINITIONS

A. "Terminal Box": The term "terminal box" as referenced on the Drawings shall be defined as "air terminal" as referenced in this Section.

1.4 SUBMITTALS

A. General: Comply with pertinent provisions of Division 1 Section "Submittals and Substitutions" and Division 15 Section "Basic Mechanical Materials and Methods".

B. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties and accessories including sound attenuator casing construction, length, lining type, method of attaching lining to casing, and access door construction. Submit sound power data with no corrections or noise reduction factors applied. Submit a schedule showing the following information for each air terminal provided:

1. Drawing designation (Item No.).
2. Room location.
3. Model number and air terminal size.
4. CFM minimum and maximum.
5. Heating coil capacity (MBH), number of rows, air pressure drop, water pressure drop, and GPM.

6. Accessories included for each air terminal.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

C. Coordination Drawings: Comply with pertinent provisions of Division 1 Section "Special Provisions", Division 15 Section "Basic Mechanical Materials and Methods", and Division 15 Section "Metal Ducts" for Coordination Drawing and Sheet Metal Fabrication Drawing requirements related to air terminals.

D. Maintenance Data: List of parts for each type of air terminal and troubleshooting maintenance guide to include in the maintenance manuals specified in Division 1 and Division 15 Section "Basic Mechanical Materials and Methods".

1.2 QUALITY ASSURANCE

A. Listing and Labeling: Provide electrically operated air terminals specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.

B. NFPA Compliance: Install air terminals according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

C. Comply with NFPA 70 for electrical components and installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide air terminals by one of the following:

1. Environmental Technologies – Model SDR.
2. Titus – Model ESV 3000.
3. Trane Co. (The) – Model VCWE.
4. Tuttle & Bailey, Hart & Cooley, Inc. – Model SDV.

2.2 GENERAL

A. Configuration: Volume-damper assembly inside unit casing. Locate control components inside protective metal shroud.

B. Air terminal boxes shall be pressure independent.

2.3 CASING CONSTRUCTION

A. Casing Construction: Galvanized or zinc coated steel sheet metal of the following minimum thicknesses:

1. Upstream Pressure Side: 0.0299-inch (22 Gage).

2. Downstream Pressure Side: 0.0299-inch (22 Gage).

B. Casing shall be mechanically assembled and sealed to form an air-tight casing.

C. Plenum Air Inlet: Round stub connections or S-slip and drive connections for duct attachment.

D. Plenum Air Outlets: S-slip and drive connections.

2.4 CASING LINING/INSULATION/ATTENUATOR

A. Casing Lining: Minimum of 1-inch thick, fibrous-glass insulation; 1.5-lb/cu. ft. density, or 3/4-inch- (13-mm-) thick, fibrous-glass insulation; 4.0-lb/cu. ft. density, complying with NFPA 90A requirements and UL 181 erosion requirements. Secure lining to prevent de-lamination, sagging, or settling.

1. Provide a non-porous scrim-stitched reinforced foil liner laminated to insulation or a 26 gage metal inner liner with insulation totally encapsulated. Provide metal angle protective strips on all exposed insulation edges.

B. Provide a sound attenuator section on each air terminal, unless otherwise indicated on the Drawings. Attenuator section shall be constructed as follows:

1. Attenuator casing shall be the same construction as that of the air terminal casing.

2. Attenuator section shall be a minimum of 36" long, shall be single piece construction, and shall be the full outlet size of the air terminal.

3. Provide an access door in the sound attenuator in accordance with "Access Door" paragraph of this Section.

4. Line attenuator with 3/4-inch thick, fibrous-glass insulation; 4.0-lb/cu. ft. density, complying with NFPA 90A requirements and UL 181 erosion requirements. Secure lining to prevent de-lamination, sagging, or settling.

a. Provide a non-porous scrim-stitched reinforced foil liner laminated to insulation or a 26 gage metal inner liner with insulation totally encapsulated. Provide metal angle protective strips on all exposed insulation edges.

2.5 DAMPER

A. Volume Damper: Damper blade shall be constructed of galvanized steel with peripheral gasket and self-lubricating bearings or shall be a cylindrical flow design with a beveled, self centering damper.

1. Maximum Damper Leakage: 2 percent of nominal airflow at 3-inch wg (750-Pa) inlet static pressure.

2. Blade type dampers shall have a damper position indicator permanently marked on the shaft and shall have a mechanical stop to prevent over-stoking.

2.6 AIRFLOW SENSOR

A. Air terminals shall be equipped with a multi-point, center-averaging or multiple point flow sensing ring type air flow sensor. The airflow sensor shall be designed to provide a differential pressure signal which is amplified 2.5 times the normal velocity pressure over the range or a minimum of 0.03"wg at 500 FPM.

2.7 HOT WATER HEATING COIL

A. Provide air terminal hot water heating coils where indicated on the Drawings. Hot water heating coils shall have capacities as scheduled on the Drawings and shall be constructed as follows:

1. 1/2-inch (13-mm) copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig (1380 kPa); and factory installed.

2. Provide 1-row or 2-row coils as scheduled on the Drawings.

3. Coil performance data shall be based on tests run in accordance with ARI Standard 410.

2.8 ACCESS DOORS

A. Provide removable panels upstream of heating coil to permit access to dampers and other parts requiring service, adjustment, or maintenance and for cleaning heating coil. Provide access door with airtight gasket and quarter-turn latches.

1. Access doors shall have a minimum size of 6" by 6".

2.9 CONTROLS

A. General: Damper operator, damper actuator, thermostat, and other devices shall be compatible with temperature controls specified in Division 15 Section "HVAC Instrumentation and Controls". Air terminal controller shall be capable to perform as (CV)-Constant Volume or (VV)-Variable Volume as scheduled on the Drawings. Air terminal box controller shall be capable of

performing all heating and cooling sequences indicated in the "Sequence of Operation" shown on the Drawings and specified in Division 15 Section "HVAC Instrumentation and Controls".

B. Air terminal controller, damper actuator, velocity pressure transducer, and control transformer shall be furnished under Division 15 Section "HVAC Instrumentation and Controls". Refer to Part 3 of this Section for installation requirements of air terminal controller, velocity pressure transducer, and control transformer.

C. Damper Position: All air terminal controllers shall have the following damper position requirements:

1. Supply air terminal with hot water coil - Normally Open.
2. Supply air terminal without hot water coil - Normally Open.
3. Exhaust air terminal – Normally Open.
4. Return air terminal – Normally Closed.

2.10 SOURCE QUALITY CONTROL

A. Testing Requirements: Test and rate air terminals according to ARI 880, "Industry Standard for Air Terminals."

B. Identification: Label each air terminal with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminals level and plumb, according to manufacturer's written instructions, rough-in drawings, original design, and referenced standards; and maintain sufficient clearance for normal service and maintenance.

1. Maintain a minimum of 18" clear in front of terminal box controller for maintenance.

B. Connect ductwork to air terminals according to Division 15 ductwork Sections.

C. Factory mount terminal box controller and actuator furnished by Division 15 Section "HVAC Instrumentation and Controls". Controls shall be installed in accordance with control manufacturer's recommendations.

1. Install pneumatic tubing from the terminal box airflow sensor to the terminal box controller transducer.

3.2 CONNECTIONS

A. Install piping adjacent to air terminals to allow service and maintenance.

B. Hot-Water Piping: In addition to requirements in Division 15 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, union or flange and pipe reducer to match coil connection; and to return with pipe reducer to match coil connection size, union or flange, manual air vent, control valve with reducers and unions to match control valve size, balancing valve, and shutoff valve.

C. Electrical: Comply with applicable requirements in Division 16 Sections.

D. Ground equipment.

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

3.3 FIELD QUALITY CONTROL

A. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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.

3.5 COMMISSIONING

A. Verify that installation of each air terminal is according to the Contract Documents.

B. Check that inlet duct connections are as recommended by air terminal manufacturer to achieve proper performance.

C. Check that controls and control enclosure are accessible.

D. Verify that control connections are complete.

E. Check that nameplate and identification tags are visible.

F. Verify that controls respond to inputs as specified.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
2. Review data in the "Operating and Maintenance Manuals" specified in Division 1 Section - "Submittals and Substitutions", in Division 1 Section - "Contract Closeout", and Division 15 - "Basic Mechanical Requirements".
3. Schedule training with Owner, through Architect, with at least 7 days' advance notice.

END OF SECTION 15845

SECTION 15854 – INDOOR CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Provide 5 indoor type, factory fabricated, custom air handling units having overall dimensions as shown on the Contract Documents. Air handling units shall be variable volume, single duct, draw-through, medium pressure (10" WG), double wall units. Operating capacity and internal components shall be of the size and quantity as listed on the Drawings.

1. This Specification Section applies to Indoor Custom Air Handling Units AHU-1, AHU-2, AHU-3, AHU-4 and AHU-5 as scheduled on the Drawings.
2. Close coordination shall be exercised between the unit manufacturer, the installing HVAC contractor, the electrical contractor, and the automatic temperature controls contractor to ensure proper operation of all components.

B. This Section includes variable-volume, custom air-handling units with the following components:

1. Economizer dampers.
2. Minimum outside air damper with integral airflow stations.
3. Mixing sections.
4. Air blending baffles.
5. Prefilters.
6. Steam pre-heat coils.
7. Steam humidifiers.
8. Chilled water cooling coils.
9. Supply fan, supports, and vibration isolation.
10. Diffuser plates.
11. Sound attenuators.
12. Final filters.
13. Discharge air sections.
14. Lighting, electrical power wiring, disconnect-switches, and junction boxes.
15. All components as shown on drawings H604, H605, and H606 "HVAC Air Handling Unit Details", and as scheduled on drawing H700 "HVAC Air Handling Unit Schedules", and specified in this Section.
16. Equipment start-up.
17. Factory performance testing.

18. Operation and maintenance manuals.

1.3 SUBMITTALS

A. Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections. Comply with pertinent provisions of Division 1 Section "Submittals and Substitutions" and Division 15 Section "Basic Mechanical Materials and Methods".

B. Submit testing procedures with diagrams and narrative indicating testing procedures prior to factory testing. Refer to Article 1.5 of this Section for further submittal requirements.

C. Submit data from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Submit product data submittals for custom air handling unit materials and equipment specified in this Section including, but not limited to:

1. Air handling unit complete with all components, controls, accessories, and installation details.
2. Steam humidifier, including performance ratings and installation details.
3. Coils (water):
    a. Submit coil construction including:
        1) Tube material and tube wall thickness.
        2) Header material and header wall thickness.
        3) Fin material and fin thickness including any special coatings.
        4) Material and gauge of frame.
        5) Number of coils, rows, fins per inch, and coil circuiting.
        6) Finned face area, finned height, and finned width.
    b. Submit certified cooling coil performance including:
        1) Sensible, latent, and total heat transfer capacity.
        2) Total air quantity (CFM) that coil selections are based upon.
        3) Cooling medium cooling coil selections are based upon and entering and leaving cooling medium temperatures.
        4) Air and water pressure drops including velocity of air and water through coil.
        5) Dry bulb temperature and wet bulb temperature for entering and leaving air coil conditions.
4. Freeze Resistant Steam Coils:
    a. Submit coil construction including:
        1) Tube material and tube wall thickness.
        2) Header material and header wall thickness.
        3) Fin material and fin thickness including any special coatings.
        4) Material and gauge of frame.
        5) Number of coils, rows, fins per inch, and coil circuiting.
        6) Finned face area, finned height, and finned width.

b. Submit certified freeze resistant steam coil performance including:

1) Total heat transfer capacity.
2) Total air quantities (CFM) that coil selections are based upon.
3) Entering steam pressure (psig) and pounds per hour of condensate produced at design conditions.
4) Air pressure drops including velocity of air through coil.
5) Dry bulb temperature for entering and leaving air coil conditions.

5. Air Filters, Filter Frames, and Filter Gauges:

a. Submit the following information for all filter types:

1) Average filter efficiency based on ASHRAE Test.
2) Initial (clean) air pressure drop at 500 feet per minute.
3) Filter media type and surface area of media per square foot.
4) Filter media enclosing frame.

b. Submit product data for all filter frames.

6. Magnehelic filter gauges for pre-filters and final filters.
7. Insulation thickness, type, and properties. . Indicate where each type of insulation is installed within the air handling unit.
8. Supply fan, complete with motor, certified performance curves, certified sound power rating, and accessories. Indicate system operating conditions.
9. Air Blenders, including product data, method of support and total air pressure drop performance.
10. Electrical Components/Wiring:

a. Electrical components including:

1) Disconnect switches.
2) Lighting fixtures and light switches.
3) Power receptacles.

b. Submit unit wiring diagrams detailing wiring for power and control systems and differentiating between manufacturer-installed and field-installed wiring.
c. Motors including (provide the following information for each motor horsepower furnished in air handling unit):

1) Motor construction, design type, and bearing construction.
2) Motor horsepower and efficiency.
3) Torque characteristics, motor frequency, and service factor.
4) Temperature rating and insulation class.
5) Noise rating and overload protection.

11. Vibration isolators including:

a. Catalog cuts of the restrained type spring isolators and support brackets.
b. Calculations showing unit weight, weight carried by each vibration isolator.
c. Identify which spring/isolator combination is required for each unit.
d. Calculations for selection of the vibration isolator support bracket and the method of attachment of the bracket to the unit base.

12. Airflow stations.
13. Dampers.

a. Economizer damper.
b. Return air damper.
c. Minimum outside air damper with integral airflow station.

14. Sound attenuators.
15. Diffuser plate, including product data, method of support and total air pressure drop performance.
16. Material gauges and finishes, including paint.
17. Construction drawing with elevation and plan views (minimum scale 3/8"=1'-0") including all dimensions, components, inlet and discharge openings, access doors, concrete pad size requirements, and equipment schedules. Show all shipping splits and mounting of accessories including air flow station cabinet, disconnect switch, etc.
18. Detail drawings including cross-sections of floor construction, structural frame layout, structural steel supports and bulkheads for coil and fan mounting, and unit section connection.

D. Product certificates signed by manufacturer of air handling unit certifying that their products comply with specified requirements including, but not limited to, air flow capacity, cooling capacity, sound data, non-condensing construction, structural integrity, and air leakage rate.

E. Field test reports indicating and interpreting test results relative to compliance with specified requirements.

F. Operation and Maintenance Manuals: Submit copies of the Operation and Maintenance Manual in compliance with Division 1 Section "Contract Closeout", Division 15 Section "Basic Mechanical Materials and Methods", and the additional requirements of Article 1.6 of this Section.

1.4 QUALITY ASSURANCE

A. The air handling unit manufacturer shall guarantee the air handling unit performance.

B. Housing shall be designed to minimize through wall metal construction in order to eliminate external water vapor condensation. The air handling unit manufacturer shall guarantee the unit casing will be airtight and non-condensing at an ambient dewpoint temperature of 65°F. The structural integrity of the unit shall prevent distortion of the unit superstructure during trucking, rigging, and installation.

C. The air handling unit components shall be fabricated in major sections in the unit manufacturer's factory and shall carry the manufacturer's nameplate. These major sections, after having all framework completely installed on their base structures, shall be joined into a one-piece complete unit assembly to ensure that all these sections will fit together properly in the field and shall be tested in accordance with Article 1.5 "Factory Inspection and Testing".

D. The HVAC contractor shall provide all field labor necessary to join the unit sections, including all electric splits after they are delivered to the site and set in place. All required field assembly shall be provided under the direct supervision of a qualified engineer employed by the unit manufacturer.

E. NFPA Compliance: Air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

F. UL Compliance: Electrical components shall be listed and labeled by UL.

G. UL and NEMA Compliance: Provide motors required as part of air handling units that are listed and labeled by UL and comply with applicable NEMA standards.

H. Comply with NFPA 70 for components and installation.

I. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

J. Coordination: Coordinate layout and installation of air handling units with piping and ductwork and with other installations.

1.5 FACTORY INSPECTION AND TESTING

A. Factory testing shall be performed on one air handling unit. The first air handling unit manufactured (AHU-1). The air handling units not required to be tested (AHU-2,3,4 and 5) shall not be manufactured until factory inspection and witnessed testing has been completed on air handling unit (AHU-1) and the air handling unit is approved by the Architect. Witnessed testing requirements shall be as follows:

1. Notify Architect and Owner's representative 2 weeks prior to any scheduled testing.
2. Provide all transportation, lodging, and meals for a designated representative of the Architect and a designated representative of the Owner to witness the factory test of the units.
3. Correct any deficiencies in the unit performance at the factory prior to shipping. Costs of additional witnessed testing and deficiency corrections required due to lack of unit performance during testing shall be borne by the unit manufacturer.
4. Prepare a formal written report at conclusion of testing interpreting test results. Submit to Architect in accordance with Article 1.3 of this Section.

B. The following factory tests are required on each manufactured air handling unit that is selected for testing.

1. Unit casing shall be designed and tested to meet a maximum leakage of 1 percent of system capacity when tested in accordance with the SMACNA HVAC Air Duct Leakage Manual. Leakage test shall be conducted at 10" S.P. Factory leakage testing shall be performed as follows:

a. Seal the supply fan discharge opening and all supply air discharge openings. Leakage test the fully assembled unit downstream of the supply fan pressure wall

under 10" S.P. and record leakage in accordance with SMACNA HVAC Air Duct Leakage Manual.

b. Seal the return air, economizer air, and minimum outside air openings. Leakage test the fully assembled unit upstream of the supply fan pressure wall under 4" negative static pressure and record leakage.

c. Measure and record panel deflection at the roof and walls under both the positive pressure test and the negative pressure test. Deflection shall be less than 1/200th of the longest span for all unit sections.

2. Unit shall be designed and tested to meet a minimum of 100 percent of scheduled system air volume (CFM) at design static pressure. Factory air volume and discharge static pressure testing shall be performed as follows:

a. Install a supply duct from discharge of unit and install calibrated airflow measuring stations, calibrated static pressure sensors and discharge air dampers in supply duct. Install airflow measuring stations in accordance with manufacturer's installation instructions. Seal return air opening. Conduct air volume test by modulating supply discharge damper to attain design discharge static pressure and record air volume. . Test results shall be reported and shall include motor amperage (all three legs), CFM, static pressure, fan RPM, motor ambient temperature, and barometric pressure, all at design conditions.

3. Units shall be designed and tested to meet maximum sound power levels at the inlets and outlets of the units as defined in the table below. In lieu of factory acoustic performance testing, unit manufacturer may submit sound power calculations stamped by a registered mechanical engineer. Stamped calculations shall only be acceptable if the internal components installed in the air handling units are the approved design equipment as scheduled and specified in the Contract Documents. Air handling units and any internal components that are "substitutions", as defined in Conditions of the Contract, Division 1 Specification Sections and Section "Basic Mechanical Materials and Methods" shall require the factory acoustic testing performed as follows:

a. Inlet and outlet sound power shall be determined by the reverberation room method as outlined in AMCA Standard 300. Sound pressure values shall be included in testing report including ambient, reference sound source, and measured values.

b. Sound power levels shall be determined at unit design airflow and static pressure.

c. Maximum sound power levels are shown in the table below.

Octave Band Sound Power Level dB Re:10-12 Watts

Frequency	63Hz	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz

Frequency	63Hz	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz
Supply Outlets AHU-1,2,3,4,5	91	85	79	64	51	40	50	62
Casing Radiated AHU-1,2,3,4,5	--	89	89	78	67	62	51	--

1.6 MANUALS AND INSTRUCTIONS

A. Operation and Maintenance Manuals: Prepare manuals in compliance with Division 1 Section "Contract Closeout", Division 15 Section "Basic Mechanical Materials and Methods", and the additional requirements of this Section. In addition to the requirements of other Sections, each manual shall include:

1. Product data cut sheets and approved shop drawings for equipment and materials as specified in Article 1.3 of this Section.

B. Instruction Seminar: Perform systems instruction seminar and walk-through with the Owner's Representatives after preparation and review of the Operation and Maintenance Manuals in accordance with Part 3 of this Section.

C. Schedule Manufacturer's factory representatives to perform equipment start-ups and instruction seminars as directed by Owner and specified in Part 3 of this Section.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver air handling units as factory-assembled modules suitably packaged and protected for overland trucking and for storing the equipment outside, exposed to the weather. Duct connection openings shall be covered and sealed with plywood or sheet metal caps.

B. Coordinate manufacturing and delivery sequence.

C. Coordinate necessary shipping splits required for trucking limitations and indicate shipping splits on shop drawing submittals.

D. Items shipped loose with the air handling units, such as filters, humidifiers, and caulking shall be suitably secured within the unit or on a separate pallet.

E. Lift and support units with manufacturer's designated lifting or supporting points.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate size and location of structural steel support members, concrete housekeeping pads, and vibration isolators.

B. Refer to Article 3.2 - "Use of Air Handling Units during Construction" in Part 3 of these specifications for restrictions on use of the air-handling unit for temporary heat and ventilation during the building construction and renovation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Haakon Industries, Vancouver, British Columbia.
2. Ventrol – Montreal, Quebec. (Air-Handling Systems Inc.)
3. Webco Engineering Co., Springfield, Missouri.
4. Temtrol - Akarche, Oklahoma

B. CASING/UNIT CONSTRUCTION

C. General

1. The overall casing shall be designed and constructed to meet the following requirements:
   a. The maximum panel deflection shall be 1/200th of the longest panel span at 10" S.P.
   b. Maximum leakage rate of 1.0 percent at 10" S.P.
   c. Capable of withstanding a static pressure of 15 inches water gage.
   d. Non-condensing at an ambient dewpoint temperature of 65°F.

D. Unit Base/Floor Construction

1. The air handling units shall be constructed on a structural steel base. The base shall be braced to support internal components without sagging or pulsating and shall be provided with lifting lugs at each corner of each section to allow for rigging of the unit. The unit perimeter base shall be constructed of 14 gauge welded 2"x6" rectangular structural steel tubing fully welded at all seams or 6" structural C-channel fully welded at all seams. Angle iron or C-channel intermediate supports placed at a maximum of 18" on center shall be provided to support all internal components and to prevent deformation of the unit during lifting. Rectangular structural steel tubing or structural C-channel support that is the full depth of the perimeter base shall be provided over the entire width of the unit at each unit section split. Intermediate structural members shall be installed at coils and fan supports and at any other point loads within the unit and shall be designed to carry the component's weight to the perimeter structural base.

a. Intermediate supports supporting the fan shall be designed to provide a maximum of 1/1000th inch deflection over the entire width of the unit.

2. The floor wearing surface shall be 3/16" thick aluminum tread plate or 1/8" thick solid diamond-plate steel. The floor-wearing surface shall have a 1½" deep, turned up lip around the entire perimeter including the unit section joints and floor shall be welded at the corners. As an option to the turned up lip at the perimeter, a continuously welded Z-bar strip at the perimeter with a turned up lip at the unit section joints with the floor welded at the corners may be provided. Each unit section shall be guaranteed watertight and capable of holding up to 1½" of standing water in each unit section without leaking. Floor shall be secured to the structural steel base with welds. The entire base shall be insulated with 4" thick, 3.0 pound per cubic foot fiberglass insulation with an effective thermal conductivity of 0.24 (BTU in./hr. sq. ft. °F) and a fire hazard classification of 25/50 per ASTM –84 and UL 723. A 22-gauge galvanized steel base under-liner shall be provided to protect and retain the insulation. Base under-liner shall be secured to the perimeter base with a liner seal angle. All base under-liner seams shall be sealed to provide a vaportight seal. All welds shall be ground and painted.

3. Minimum 1¼" diameter floor drains shall be provided in each unit section. Drain piping shall be stainless steel and shall terminate at the side of the unit with a screwed nipple and cap. Drains shall be continuously welded to the unit floor and the perimeter base.

E. Unit Section Splits

1. The unit section splits shall be bolted and gasketed along the entire perimeter. Floor shall be bolted at 12" intervals using 3/8" zinc plated bolts and nuts or continuously welded. Section joints at walls and roof shall be screwed or bolted at 8" in intervals along the entire perimeter. Exterior joints shall be caulked with silicone or provided with a galvanized seal cap, screwed to the exterior panel.

F. Wall Construction

1. Unit casing shall be fabricated from minimum16-gauge, maximum 18" wide, galvanized steel, 4-inch thick, three break type panels, with inner liner. The inner liner shall be a wash down type and shall be continuous across panel splits. The inner liner shall also overlap the turned up lip of the floor or perimeter Z-bar by 1" and neoprene tape shall be installed between the wash down liner and the panel return lip to prevent thermal conductance to the exterior of the unit. Inner liner shall be secured to the return lip of the wall panels and the upturned lip of the floor or Z-bar with ¼" zinc plated, self-tapping screws at a minimum of 8" on center. Cooling coil and humidifier section liner shall be 0.05" thick non-perforated sheet aluminum, supply fan sections shall be 0.04" thick perforated aluminum liner, and all other sections shall be 20-gauge solid non-perforated galvanized steel or 0.05" thick non-perforated sheet aluminum. Insulation shall be minimum 4" thick, non-combustible, odor and vermin proof, and shall be resistant to mildew. Insulation density shall be 3.0 pound per cubic foot fiberglass insulation with an effective thermal conductivity of 0.24 (BTU in./hr. sq. ft. °F) and a fire hazard classification of 25/50 per ASTM –84 and UL 723. Insulation behind all perforated inner liner shall meet or exceed the erosion requirements of UL-181.

2. Panels shall be sealed with two ¾" wide strips of butyl between each panel and shall joined together using ¼" hex head, self-tapping screws a maximum of 8" on center. Exterior panel joints shall be sealed with silicone after the unit is painted.
3. Supply fan interior septum walls shall be fabricated from minimum16-gauge galvanized steel, maximum 18" wide, 4-inch thick, three break type panels, and have a maximum deflection of 1/200th of the longest panel span at 150 percent of design operating pressure. The inner liner facing the fan shall be 0.04" thick perforated aluminum liner. Wall shall be insulated with 4" thick 3.0 pound per cubic foot fiberglass insulation with a fire hazard classification of 25/50 per ASTM –84 and UL 723 and erosion requirements that meet or exceed UL-181.

G. Roof Construction

1. Roof panels shall be identical to wall panels. Channels, aprons, and corner joints shall be used to secure the roof panels to the wall panels. Provide cap strip or turn down roof panels around the entire roof perimeter weld or caulk at corners.

H. Acoustic Performance of Panels

1. The manufacturer shall have published literature available stating the sound absorption coefficient of panel systems obtained using ASTM method Test for Sound Absorption of Acoustical Materials in Reverberation Rooms (ASTM Designation C423-90A), and the sound transmission loss obtained using procedures conforming to ASTM designations E90, E413, and other pertinent standards. Perforated panel system sound data shall meet the following criteria for sound transmission losses and absorption coefficients:

Frequency	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz
Transmission Losses (dB)	18	25	37	46	48	54
Absorption Coefficient	0.74	1.25	1.11	1.01	1.99	0.94

I. Economizer, Return, Outside Air, and Supply Air Duct Connections

1. Supply air discharge air openings shall be provided with long radius bellmouths, mounted flush with the interior liner of the unit casing and sealed to the interior casing liner. The exterior bellmouth openings shall match the duct size indicated on drawings and shall extend a minimum of 1" beyond the exterior casing wall to allow for duct connection.

2. Return, economizer, and outside air duct connection shall have 2"x 2" angles secured to the exterior of unit to allow for field connection of ductwork. Size of openings shall match duct sizes indicated on drawings.

J. Air Blending Baffles:

1. Provide 16 gauge perforated galvanized steel air blending baffle plate as shown on the Contract Documents. The air blending baffle plate shall be supported with channels on each side to prevent distortion. The air blending baffle plate shall be welded or bolted to the air handler casing for secure attachment under operating conditions. The air blending

baffle plate shall be engineered and manufactured to provide even mixing between outdoor and return air within the mixing plenum to provide less than 6°F of stratification across the cooling coil bank.

K. Drain Pans:

1. Full length drain pans shall be provided for each cooling coil bank. The pans shall be fully welded 16 gauge, Type 304 stainless steel or 0.09" thick, fully welded, aluminum. Where cooling coils are stacked, intermediate drain pans shall be provided and shall be constructed the same as the base drain pan. Intermediate pans shall be double sloping and shall be provided with one 1" downcomer of Type 304 stainless steel pipe or aluminum pipe. Each downcomer shall drain to the lowest drain pan.
2. Each pan shall be pitched in two planes toward the condensate outlet. The outlet shall be a 2" minimum 304 stainless steel NPT nipple. All pans shall be installed to be completely self draining. Pipe type 304 stainless steel pipe or aluminum pipe to side of the unit base. Ready for field connection of a P-trap.
3. The primary pan shall be extended from the upstream face of the coil assembly to 18" minimum downstream of the discharge face of the cooling coil. Intermediate pans shall extend from the upstream face of the coil to 9" downstream of the coil assembly.
4. The primary drain pan shall be a minimum of 3" deep. Intermediate drain pans shall be a minimum of 1" deep.
5. Pans shall extend 1" beyond headers and U-bends on each side of coil.
6. Insulate the bottom drain pan with insulation to avoid condensation on the base of the drain pans. Insulation shall be the same as the floor insulation.

L. Diffuser Plate:

1. Provide 16 gauge galvanized steel diffuser plate as shown on the Contract Documents. Diffuser plate shall be supported with channels on each side to prevent distortion. Diffuser plate shall be engineered and manufactured to provide even airflow over downstream components within 36 inches.

M. Access Doors and Removable Access Panels:

1. Provide service/access doors of the same construction as the air handling unit casing for all unit sections containing equipment requiring service, where dampers or damper operators are installed or areas for cleaning of unit components such as coils, etc., is required. Access doors shall be equipped with continuous gaskets and shall fit in the doorframe in a manner to guarantee no leakage.
2. Each access door shall have a built-in static pressure probe port for ease of pressure readings across various internal components and to limit unnecessary or unauthorized access inside the unit. Pressure probe port shall be Ventlok #699.
3. Each access door shall be mounted with two stainless steel butt hinges to prevent door racking and leakage. Two cast aluminum Vent-Lok #260 handles operable from either side shall be provided. Provide self-locking nuts for handles and stainless steel hardware to assure long-term, proper door operation.

4. Each door shall contain a thermal double pane glass window, a minimum of 10 inches by 10 inches or 10" in diameter, installed at eye level and properly sealed to operate safely against suction or pressure.
5. Access door sizes and orientation shall be as indicated on Contract Documents. Doors shall open against pressure; positive-open in, negative-open out.
6. Removable access panels shall be provided in unit sections where large components will have to be accessed for service and maintenance. Panels shall be of the same construction as doors. Panels shall be sized to allow for the removal of the unit component without disassembly of the internal component.

    a. Provide removable panels at fan section, cooling coil, and humidifier and steam pre-heat coil as shown on drawing details.

N. Internal Component Safing

1. Provide 16 gauge stainless steel blank-off plates to prevent air bypass around cooling coils.
2. Provide 16 gauge galvanized steel blank-off plates to prevent air bypass around the perimeter of each filter bank.
3. Provide 16 gauge galvanized steel blank-off plates to prevent air bypass around heating coils.

O. Supply Fan Support:

1. Provide a welded angle iron support frame for the air handling unit supply fan inertia base. Angle iron support shall be bolted to the intermediate structural steel floor supports and the entire assembly shall be designed for provide a maximum of 1/1000th inch deflection over the entire width of the unit.

P. Coil Support:

1. General (all coil support racks):

    a. Wherever coils are stacked, each upper coil shall be independently supported on structural steel tubing to allow the lower or upper coil section to be removed without disturbing any other coil section. Coils removeable in the downstream direction.
    b. Coil support structure shall be designed to support the full operating weight of the coil with a factor of safety of 4.0. Support rack shall be bolted or welded to the unit base, intermediate structural supports.

2. Cooling Coils:

    a. The cooling coils shall be mounted on a 16-gauge, tubular frame, stainless steel rack.

3. Steam distributing Steam Heating Coil Support:

a. The steam distributing type steam heating coils shall be mounted on a 16-gauge, tubular frame, galvanized steel rack. Coils removeable in the downstream direction.

Q. Piping and Electrical Penetrations:

1. All piping and electrical conduits that penetrate the unit walls shall be provided with a double wall, insulated, escutcheon plate sealed with a gasket both interior and exterior. Escutcheon plate shall be designed to prevent any condensation inside the unit walls.
2. Provide pipe sleeves through unit walls for chilled water, steam, and steam condensate piping that is to be field installed. Provide number and size of sleeves as indicated on the Drawings.

R. Finishes:

1. The base and unit frame shall be painted with an industrial direct to metal finish with corrosion inhibitors built-in.
2. The exterior panels shall be finished with an air dried industrial alkyd enamel that meets the following standards:
   a. ASTM B-117: Salt spray resistance, 5% salt fog at 95°F for 500 hours.
   b. ASTM D-2247: Humidity Resistance100% salt fog at 95°F for 500 hours.
3. All ungalvanized steel, fan support, and inner floor liner shall be coated with one (1) coat of primer and two (2) coats of enamel finish paint. Aluminum tread plate shall not require painting.
4. All welds shall be ground smooth and painted.

S. Identification:

1. Provide equipment nameplate with data engraved or stamped for permanent attachment on air handling unit. Nameplate shall provide the following information:
   a. Manufacturer, product name, model number, and serial number.
   b. Capacity, operating and power characteristics, and essential data.
   c. Labels of tested compliance's.
2. Provide each access door with permanent identification of the following:
   a. Section identification, airflow direction, and OSHA required safety warnings.
3. Coil and humidifier piping connections shall be clearly and permanently identified with "SUPPLY" and "RETURN" identifiers.

2.2 VIBRATION ISOLATION - INERTIA BASES

A. Inertia Bases: Subject to compliance with requirements, provide inertia bases by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.
   a. Model: Type K.

2. Amber Booth Company, Inc.; Houston, Texas.
   a. Model: Type CPF.

B. Inertia Base: Factory-fabricated, welded, structural-steel bases ready for field-applied, cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate a minimum 4" overlap of the supported equipment.
3. Perimeter steel members shall have a minimum depth of 1/12 of the longest span, but not less than 6" deep and not greater than 14" deep. Provide concrete reinforcement bars or angles welded on 6" centers in both directions. Reinforcement layer shall be placed 1-1/2" from the bottom of the base. Provide a second layer of reinforcement 1-1/2" from the top of the base for all bases larger than 120" in any direction.
4. Support Brackets: Factory-welded steel angles on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
5. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

C. Install inertia bases under each supply fan.

D. Install seismic snubbers on isolated equipment. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

2.3 VIBRATION ISOLATION – SPRING MOUNTED VIBRATION ISOLATORS

A. Spring Mounted Vibration Isolators: Subject to compliance with requirements, provide free-standing spring mounted vibration isolators by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.
   a. Model: Type SLF.

2. Amber Booth Company, Inc.; Houston, Texas.
   a. Model: Type SW.

B. Spring Mount type Vibration Isolators:

1. Provide restrained type spring mounts designed to resist seismic forces in all directions.
2. Material finishes as follows::
   a. Springs cadmium plated or electro-galvanized.
   b. Hardware cadmium plated or zinc electroplated.
   c. All other metal parts hot-dip or hot spray galvanized.
3. Deflection: Minimum 3 inch static deflection.

4. Minimum 1/4" thick neoprene acoustical base pad or cup on under side.
5. Designed and installed so that the ends of the springs remain parallel.
6. Built-in vertical limit stops with minimum 1/4: clearance under normal operation.
7. Tapped holes in top plate for bolting to equipment.
8. Capable of supporting equipment at fixed elevation during equipment installation. Installed and operating heights shall be identical.
9. Adjustable and removable spring pack with separate neoprene isolation pad.

2.4 VIBRATION ISOLATION-THRUST RESTRAINTS

A. Thrust Restraints: Subject to compliance with requirements, provide thrust restraints by one of the following:

1. Mason Industries, Inc.; Hauppauge, New York.
   a. Model: Type WB.

2. Amber Booth Company, Inc.; Houston, Texas.
   a. Model: Type TRK.

B. Install thrust limits at centerline of thrust, symmetrical on either side of each supply fan.

C. Thrust Restraints: Combination coil spring and elastomeric insert with spring and insert in compression and with a load stop. Include rod and angle-iron brackets for attaching to equipment.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

2.5 HOUSED CENTRIFUGAL FANS

A. Fan Manufacturers: Subject to compliance with requirements, provide centrifugal supply fans by one of the following:

1. Cook (Loren) Co.
   a. Model: CA-DWDI.

2. Twin City Fan Co.

a. Model: Type BAF.

3. McQuay International; Barry Blower Div.

a. Model: VersaCon Series VCR.

B. General

1. Fans shall be class III construction, double width, double inlet type with airfoil type wheels
2. Factory fabricated and assembled, factory tested, and factory finished, with indicated capacities and characteristics as indicated in the Contract Documents.

C. Fan Construction

1. Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.
2. Formed- and reinforced-steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and doors or panels to allow access to internal parts and components.
3. Brace panels with steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
4. Fan fabrication class shall be AMCA 99 Class III.
5. Housing shall be a horizontal flanged split housing with bolted construction.

a. Brackets suitable for horizontal or vertical mounting.

D. Airfoil Wheel Construction

1. Steel construction with smooth curved inlet flange; heavy back plate; hollow die-formed airfoil-shaped blades continuously welded at tip flange and back plate; cast-iron or cast-steel hub riveted to back plate and fastened to shaft with set screws.

E. Shafts

1. Statically and dynamically balanced and selected for continuous operation at the maximum rated fan speed and motor horsepower (HP), with final alignment and belt adjustment made after installation.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of the first critical speed at the top of the fan's speed range.

F. Bearings

1. Grease-lubricated shaft bearings shall be self-aligning, pillow-block type; tapered roller bearings with double-locking collars and 2-piece, cast-iron housing.

a. Roller-Bearing Rated Life: AFBMA 11, L-10 of 200,000 hours.

G. Belt Drive/Pulleys/Belts

1. Belt drive shall be factory mounted, with final alignment and belt adjustment made after installation.
2. Belt drive service factor shall be 1.5; based on fan motor maximum developed torque.
3. Fan pulleys shall be cast iron or cast steel with split, tapered bushing, dynamically balanced at factory.
4. Motor pulleys shall be fixed pitch. Select pulley so pitch adjustment is at the middle of the adjustment range at fan design conditions.
5. Belts shall be oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
    a. Provide belt guards fabricated to comply with OSHA and SMACNA requirements; 0.1046-inch- thick, 3/4-inch diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
6. Provide adjustable motor mount suitable for belt tensioning.

H. Fan Accessories

1. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
2. High pressure lube lines extended to unit exterior by the fan access door.

I. Factory Finish

1. Enamel or prime coat before assembly with 2 coats of paint. Prime coating on aluminum parts is not required.

J. The following factory tests are required as indicated:

1. Sound Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA Seal.
2. 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."

2.6 MOTORS

A. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.

B. Frequency Rating: 60 Hz.

C. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range.

D. Motors Shall be Suitable for use with Variable Frequency Controllers: 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 H.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

E. Service Factor: 1.15.

F. Motor Construction: NEMA MG-1, general purpose, continuous duty, Design B.

G. Bearings: The following features are required:

1. Ball or roller bearings with inner and outer shaft seals rated for minimum 20,000 hours.
2. Grease lubricated.

H. Enclosure Type: The following features are required:

1. Open Drip-proof.

I. Overload Protection: Built-in, automatic reset, thermal overload protection.

J. Noise Rating: Quiet.

K. Efficiency: Motors shall be premium efficient design and shall have the following minimum nominal efficiency:

1. 100.0 hp: 95.4 percent

L. Nameplate: Indicate full identification of manufacturer, ratings, characteristics, construction, and special features.

1.72.7 CHILLED WATER COILS

A. Manufacturers: Subject to compliance with requirements, provide chilled water coils by one of the following:

1. Heatcraft Inc.; Heat Transfer Division.
2. Dunham-Bush, Inc.
3. Carrier Corporation.
4. Trane Co. (The).
5. USA Coil and Air.
6. Super Radiator Coils.

B. General: Provide number of coils having capacities as scheduled on the Contract Documents.

C. Description: Self-draining coil fabricated to ARI 410.

D. Piping Connections: Copper or brass, Male Pipe Threaded (MPT), on same end with brazed connections to coil headers.

1. Provide each coil connection with caps for thread protection.

E. Tubes: Copper, complying with ASTM B 75 (ASTM B 75M).

1. Provide the number of rows of tubes as scheduled on the Contract Documents.
2. Tube Diameter: 0.625 inch (5/8")(15.9 mm)
3. Minimum Tube Thickness: 0.035 inch (0.875 mm).
4. Return bend fitting wall thickness shall be equal to or greater than the tube wall thickness.

F. Fins: Aluminum, extended surface type, 0.095 inch thick. (nominal 0.010")

1. Provide number of fins per inch as scheduled on the Contract Documents.
2. Provide plate fins with integral collars to provide continuous surface cover over the tube and provide uniform fin spacing.

G. Fin and Tube Joint: Mechanical bond.

H. Headers: Seamless copper tube, 0.60 inch tube thickness with brazed joints. Provide copper drain and vent connections.

I. Frames: Stainless steel, type 304, 16 gauge (0.0625 inch) (1.6 mm).

1. Provide an intermediate support for coils over 72 inches in length. Provide two intermediate supports for coils over 96 inches in length. Intermediate support shall be 16 gauge, type 304, stainless steel.

J. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.

1. Coils shall meet scheduled performance indicated on the Contract Documents.
2. Coil face velocity shall not exceed 500 feet per minute.

K. Working Pressure Ratings: 200 psig (1380 kPa) water, 300 deg F (148 deg C).

L. Source Quality Control: Test to 300 psig (2070 kPa), air pressure under warm water.

1. Coils shall be degreased to remove any residual oil remaining from the manufacturing process.

1.82.8 STEAM DISTIBUTING HEATING COILS

A. Manufacturers: Subject to compliance with requirements, provide steam coils by one of the following:

1. Steam Coils:

   a. Heatcraft Inc.; Heat Transfer Division.

   b. Dunham-Bush, Inc.

   c. Trane Co. (The).

   d. USA Coil and Air.

   e. McQuay.

B. Description: Steam distributing, tube-in-tube steam distributing coil fabricated to ARI 410.

C. Piping Connections: Same end. Provide threaded connections for coil connections 2 inches and smaller and flanged connections for coil connections 2-1/2 inch and larger.

1. Provide each coil connection with caps for thread protection and plugs for flanged connections.

D. Tubes: Copper, complying with ASTM B 75 (ASTM B 75M).

1. Provide the number of rows of tubes as scheduled on the Contract Documents.

2. Provide staggered tube design for two row coils.

3. Outer Tube Diameter: 1.0 inch **(25.4 mm)**.

4. Minimum Outer Tube Thickness: 0.035 inch (0.875 mm).

5. Inner Tube Diameter: 0.625 inch (5/8")(15.9 mm).

6. Minimum Inner Tube Thickness: 0.018 inch (0.45 mm).

7. Inner tube shall be orficed to provide uniform steam distribution within the outer tube.

8. Inner tube shall be centered and supported within the outer tube with stainless steel holding clips.

9. Tubes shall be pitched in the coil casing, toward the connection side of the coil a minimum of ¼" per foot.

E. Fins: Aluminum, extended surface type, 0.095 inch thick. (nominal 0.010")

1. Provide number of fins per inch as scheduled on the Contract Documents.

2. Provide plate fins with integral collars to provide continuous surface cover over the tube and provide uniform fin spacing.

F. Fin and Tube Joint: Mechanical bond.

G. Supply and Return Headers: Seamless copper tube, 0.60 inch tube thickness with brazed joints.

1. Provide baffle plates in the supply header opposite the supply steam connection to ensure uniform diffusion of entering steam within the supply header.

2. Provide intruded tube holes in both the supply and return header to allow for added brazing surface and flexibility during coil expansion and contraction.

3. Provide copper drain and vent connections.

H. Frames: Galvanized steel, 16 gauge (0.0625 inch) (1.6 mm).

1. Provide an intermediate support for coils over 72 inches in length. Provide two intermediate supports for coils over 96 inches in length. Intermediate support shall be 16 gauge, galvanized-steel.

I. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.

1. Coils shall meet scheduled performance indicated on the Contract Documents.
2. Coil face velocity shall not exceed 1000 feet per minute and velocity shall not be lower than 700 feet per minute.

3. Working Pressure Ratings: 100 psig (690 kPa) steam, 400 deg F (204.4 deg C).

J. Source Quality Control: Test to 300 psig (2070 kPa), air pressure under warm water.

1. Coils shall be degreased to remove any residual oil remaining from the manufacturing process.

2.9 DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Outside Air Economizer Damper:
   a. TAMCO – Series 9000
   b. Ruskin – CD40x2

2. Return Air Damper:
   a. TAMCO – Series 1000
   b. Ruskin – CD50
   c. CESCO – CDAF-PB

3. Combination Minimum Outside Air/Airflow Station Damper:
   a. Ruskin – Model AMS50

B. Outside Air Economizer Damper:

1. Extruded aluminum damper frame shall not be less than .080" thickness. Damper frame to be 4" deep and shall be insulated with polystyrene on four sides or have a thermally broken frame.

2. Blades to be extruded aluminum, internally insulated with non-CFC, expanded polyurethane foam and shall be thermally broken or provide a 4" insulating air gap between two sets of parallel blade dampers. Complete blade assembly shall have an insulating factor of R-2.29 and a temperature index of 55.

3. Bearings to be comprised of an inner bearing fixed to a minimum 7/16" aluminum hexagon blade pin rotating within an outer bearing inserted in frame or molded synthetic.

4. Linkage hardware shall be installed in frame side and be constructed of aluminum and corrosion resistant, zinc & nickel plated steel.

5. Dampers to be designed for operation in temperature ranging between -40°F and 212°F.

6. Dampers shall be parallel blade action.

7. Air leakage through a 48" x 48" damper shall not exceed 4.12 cfm/sq.ft. at 4" water gauge differential static pressure at standard air conditions. Leakage data to be certified under the AMCA certified ratings program.

8. Pressure drop of a fully open 48" x 48" damper shall not exceed .03" water gauge at 1000 fpm.

C. Return Air Damper:

1. Return air dampers shall be low leakage parallel blade dampers. Dampers shall be constructed of extruded aluminum including blades and frame (minimum 12 gauge). Blades shall be airfoil shape, heavy gauge aluminum. Blade seals shall be replaceable extruded vinyl or silicone. Damper blades shall be parallel blade orientation.

D. Combination Minimum Outside Air/Airflow Station Damper:

1. General Description and Performance Data:

a. Provide an air monitoring station that incorporates a low leakage control damper with air monitoring blades and air straightener section in one assembly. Airflow sensing blades shall sense the airflow velocity. Using the velocity information provided from the sensing blades, the controller will calculate a CFM value. This value will then be compared to the design setpoint indicated on the Contract Documents. Based on the difference between the actual CFM reading and the desired setpoint, the controller will interact with the control damper actuator to position the damper blades to achieve the desired airflow.

b. Assembly shall be capable of operating between -22°F and 140°F and shall be capable of sensing airflow over a range from 400 to 5,000 FPM face velocity, with an accuracy of ±5%.

2. Damper/StraightenerConstruction:

a. Damper frame shall be fabricated from 4"x1"x0.081" thick, 6063-T5 extruded aluminum channel with mounting flanges on both sides of frame.
b. Control damper blades shall be airfoil shaped, heavy gauge, 6063-T5 extruded aluminum.
c. Airflow monitoring blades shall be airfoil shaped, heavy gauge, 6063-T5 extruded aluminum with a total pressure measuring chamber and a static pressure measuring chamber. Blades shall be fixed in the 16 gauge galvanized steel frame.
d. Provide flexible metal compression type jambs seals along the control damper sides. Provide ruskiprene seal along control damper blade edges.
e. Bearings shall be molded synthetic.
f. Linkage shall be stainless steel and concealed within the frame.
g. Axles shall be minimum ½" diameter plated steel, hex shaped, mechanically attached to the blade.
h. Provide an air straightener section consisting of 3000 series aluminum alloy honeycomb. Straightener shall be contained in a 5" long, 16 gauge galvanized steel sleeve that shall be attached to the monitoring blade frame.
i. Frame shall be suitable for mounting inside the air handling unit as indicated on the Contract Documents.

3. Damper Controller:

a. Each air monitor/damper shall include 24VAC electric modulating motor and an application specific controller designed for this application furnished by the damper manufacturer. Each integral air monitor/damper shall be calibrated in an AMCA registered laboratory and a certification chart shall accompany the air monitor/damper.

E. Damper Actuators:

1. Outside Air Economizer Damper Actuators:

a. Furnished and installed by Division 15 Section "HVAC Instrumentation and Controls".

2. Return Air Damper Actuators:

a. Furnished and installed by Division 15 Section "HVAC Instrumentation and Controls".

3. Combination Minimum Outside Air/Airflow Station Damper Actuators:

a. Furnished and installed under this Section.

2.10 FILTER SECTION

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Pre-filters (45 Percent):

a. Precisionaire – Model 62R

2. Pre-filter Frame:

   a. Farr – Type 8.

3. Final Filters (95 Percent) and Final Filter Frame:
   a. Viskon Aire Model V-95 – 26" Deep, 8 pocket (for 24"X24" modules)

4. Final Filter Frame:

   a. Farr – Type 8.

B. Pre-Filter and Final Filter Frame:

1. Filter bank framing shall be 16 gauge galvanized steel filter holding frame system.

2. Frames shall be cut to size and pre-punched for easy assembly into modules of size and capacity as indicated on Contract Docoments.

3. Framing shall be permanently gasketed with polyurethane foam to prevent bypass of unfiltered air.

4. Framing system shall incorporate filter fasteners to provide positive sealing for each filter to facilitate installation and removal of cartridges without use of tools, nuts, or bolts.

5. Frames shall be suitable for upstream filter servicing, as indicated on the Contract Documents.

6. Provide a continuous 3/16" thick by 5" wide galvanized steel vertical support member to prevent excessive deflection or distortion of pre-filter and final filter banks.

   a. One continuous vertical support member shall be provided for every two columns of pre-filter frames.
   b. One continuous vertical support member shall be provided for every column of final filter frames.

7. Pre-filter and final filter frames shall be installed and sealed by air handling unit manufacturer.

C. Pre-Filters (25-30 Percent):

1. Comply with NFPA 90A.

2. Prefilters shall be 2-inch deep media, medium efficiency, Class II disposable bag type. Filters shall consist of a non-woven cotton and synthetic media, media support grid, and enclosing frame. The media shall have an average efficiency not less than 40 percent on ASHRAE Test Standard 52-76. The effective media area shall not be less than 7 square feet of media per 1.0 square foot of filter face area. A 24"X24" filter module when oper-

ating at a flow rate of 2000 CFM shall have an initial clean pressure resistance of no more than 0.24 inches of water gauge.

3. Enclosing Frames shall be constructed of a rigid, heavy-duty, high wet-strength beverage board, with diagonal support members bonded to the air entering and air exit side of each pleat to ensure pleat stability. The inside periphery of the enclosing frame shall be bonded to the filter pack, thus eliminating the possibility of air bypass.

D. Final Filters (90-95 Percent):

1. Comply with NFPA 90A.

2. Final filters shall be 26-inch deep, of rigid structure, and incorporating a bag filter type design. The filter medium shall be non-shedding, wet-process, glass fiber paper. A polyurethane sealant shall be used to encapsulate the media to the filter casing preventing any bypass. The filter shall be tested per ASHRAE Standard 52-76 and have an average dust spot efficiency of 95 percent. A 24"X24" filter module when operating at a flow rate of 2000 CFM shall have an initial clean pressure resistance of no more than 0.55 inches of water gauge.

E. Provide the following sets of filters:

1. AHU-100,101,102, and 103:

a. Pre-filters (25-30 Percent): 2 sets.

b. Final filters (90-95 Percent): 2 sets.

c. The first set of filters shall be installed in the unit prior to unit start-up and shall be remain in place for the duration of the construction project. The second set of filters shall be installed after construction is complete and prior to any testing and balancing. Refer to Article 3.2 "Use of Air Handling Units during Construction" in Part 3 of these specifications for restrictions on use of the air handling unit for temporary heat and ventilation during the building construction and renovation and additional sets of filter required during the construction phase of the Project.

2.11 FILTER GAUGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Dwyer Magnahelic Type 2003 AF.

B. Each filter bank shall be provided with factory mounted and piped Magnahelic pressure gauges.

1. Provide filter gauges with the following scales:

a. Pre-Filter (25-30%): 0-1" water gauge.
b. Final Filter (90-95%): 0-2" water gauge.

2.12 STEAM HUMIDIFIER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Dri-Steem Humidifier Co.

a. Model – UltraSorb.

B. Humidifier banks shall be factory installed in the air handling unit in accordance with humidifier manufacturer's recommendations. Factory installation shall include provisions for unit wall penetrations as outlined under unit construction.

C. Tube bank shall consist of a horizontal header and necessary quantity of vertical dispersion tubes necessary to achieve the required steam absorption distance. Header shall be constructed of stainless steel and be fitted with 1-1/2" tee outlets for dispersion tube connections. The dispersion tubes shall extend the interior height of the air handling unit and shall be fitted with two rows of high temperature inserts arranged in a V-pattern. Each insert shall extend through and into the center of the dispersion tube and incorporate a properly sized calibrated orifice.

D. Provide humidifier bank support for two humidifiers mounted side by side as indicated on the Drawings. Humidifiers shall be installed with proper vertical clearance below the condensate header to allow proper steam trap installation.

2.13 SOUND ATTENUATORS

A. Manufacturers: Subject to compliance with requirements, provide sound attenuators by one of the following:

1. Vibro-Acoustics.
2. IAC-Industrial Acoustics Company.
3. United McGill Corporation.

B. General: Provide factory-fabricated, sound attenuators with geometry, size, capacity, and acoustic performance characteristics as required to meet the maximum sound power levels indicated in Article 1.5 – Factory Inspection and Testing.

C. Sound attenuators provided for each unit shall be constructed in accordance with the following:

1. Sound attenuators shall be constructed in accordance with ASHRAE and SMACNA standard for 150 percent of the scheduled maximum unit static pressure. Material gages indicated shall be increased as required to meet the system pressure classifications and

shall, as a minimum, not fail structurally when subjected to a differential pressure of 15" water column.

2. All sound attenuator casings shall be lockformed and sealed.

3. All perforated metal shall be adequately stiffened to in sure flatness and form. All spot welds shall be painted.

4. All sound attenuator inlet and outlet connection dimensions must be equal to the full size of the unit casing. Duct transitions to inlet or outlet of the sound attenuators are not acceptable.

5. Fabricate sound attenuators to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Provide cross or trapeze angles for rigid suspension as required to meet system requirements. Do not use nuts, bolts, or sheet metal screws for unit assemblies.

6. Fabricate casings with a minimum of 22-gauge (0.034-inch thick), solid sheet metal for outer casing and 26-gauge (0.022-inch thick), perforated sheet metal for inner casing.

7. Sound attenuator pressure drops shall not exceed those indicated on the Contract Documents. Sound attenuator pressure drop measurements shall be made in accordance with the ASTM E-477-96 test standard. Tests shall be conducted and reported on the identical units for which acoustical data is presented.

2.14 AIRFLOW STATION

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Airflow Station Probes:
   a. Air Monitor Corporation - Volu-Probe/FI.

2. Airflow Station Flow Meter:
   a. Air Monitor Corporation – Type "M".

3. Electronic Differential Pressure Transmitter:
   a. Air Monitor Corporation – VELTRON Series 1000C.

B. Provide on the supply fan, air flow traverse probes factory mounted by the air handling unit manufacturer in the fan inlet capable of continuously measuring the fan capacity.

1. The fan inlet air flow traverse probes (two per inlet) shall contain multiple total and static pressure sensors placed at concentric area centers along the exterior surface of the cylindrical probe and internally connected to their respective averaging manifolds.

2. The fan inlet probe shall have dual end support swivel brackets suitable for mounting in the fan inlet bell and shall be of aluminum construction with hard anodized finish.

3. The probes shall be capable of producing steady, non-pulsating signals of standard and total static pressure without need for flow corrections or factors, with an accuracy of 3 percent of actual flow over a fan operating range of 6 to 1 turndown

C. Provide with the air flow traverse probes a NEMA 1 cabinet with air flow indication gauge and electronic differential pressure transmitter for the supply fan and the minimum outside air flow station. The cabinet shall be factory mounted by the air handling unit manufacturer on the exterior of the air handling unit supply fan section as shown on the Drawing.

1. The air flow meter shall be mounted flush on the cabinet front door. The meter shall consist of a dual-scale, diaphragm-actuated differential pressure gauge. Gauge to read in cubic feet per minute (CFM) and in feet per minute (FPM). Meter to be complete with internal tubing, barb fitting for 1/4" O.D. tubing and furnished with a plastic data plate listing the system, air flow station number, fan number and design air volume.

2. The electronic differential pressure transmitter shall be capable of receiving signals of duct and reference static pressure and of amplifying and scaling the sensed differential pressure of inches W.C. into a 4-20mA DC or 0-5 VDC outlet signal linear to differential pressure. The differential pressure transmitter shall be capable of the following performance and application criteria:

3. Performance Characteristics Common to All Transmitters

   a. Reference Accuracy (Includes Non-Linearity, Hysteresis, and Non-Repeatability):
      1) $\pm$0.5 Percent of Span
   b. Output Signal:
      1) 4-20mA DC or 0-5 VCD Standard
   c. Power Supply:
      1) 12 to 40 DC unregulated: 2 wire, 4 to 20mA DC: 3 wire, 0 to 5 VDC.
   d. Integral Zeroing Means:
      1) 3-way zeroing valve with manual switch.
   e. Temperature Effect:
      1) $\pm$2.0 percent of full span from 40°F to 120°F

4. The transmitter shall not be damaged by over-pressurization up to 20 times greater than span and shall be furnished with a factory calibrated span and integral zeroing means. The transmitter shall be housed in a molded polyethylene (NEMA 12 steel) enclosure with external signal tubing, power and output signal connections.

D. Pneumatic tubing from the fan inlet probes to the gauge cabinet shall be factory installed by the air handling unit manufacturer. Pneumatic tubing shall be copper with maximum unsupported length of 36". Tubing shall be soldered or brazed, except at equipment and at shipping breaks where compression fittings shall be used. Tubing shall be pressure tested and purged with dry, oil-free compressed air before connections are made.

2.15 ELECTRICAL COMPONENTS/WIRING

A. The air handling unit shall be provided with pre-wired, non-corroding vapor tight, double-lamp, fluorescent lights in each unit compartment as shown on the Contract Documents. Lighting size and layout shall provide a minimum of 10 foot-candles in all compartments.

B. Lights shall have 120V cold weather ballast and shall be UL labeled. Light switches shall be mounted in bell boxes on the exterior of each unit compartment. Unit lighting shall be wired to turn on all of the lighting from a single switch.

C. Provide a minimum of two (2) duplex electrical outlets (20 amp) for operation of power tools by the facility maintenance personnel.

D. Lighting, light switches, and outlets shall be wired in GRC type conduit by the unit manufacturer at the factory and terminated at two single-points for field connection to a 120 V single phase circuit.

E. Provide junction box and "seal tight" connections to allow power to be connected from one section to the next when joining units in the field.

F. Disconnect: Provide factory-assembled, heavy-duty type, non-fused disconnect switch, 600V, padlockable, mounted outside the fan section. Connections shall be provided using conduit (GRC) and "seal-tight" between disconnect and motor.

G. Provide factory installed 120V power wiring to the following factory installed controls:

1. Combination minimum outside air/airflow station damper control power transformer furnished with airflow station controller.

2. Airflow station cabinet control power transformer furnished with airflow station controller.

H. Wiring and Conduit:

1. The unit wiring shall be stranded copper wire sheathed in a THHN covering, which will be distributed through the unit in GRC type conduit; the use of aluminum wire or flexible BX cable is prohibited.

2. Provide a terminal strip in the electric control center. This terminal strip shall have enough terminals to allow for the connection of components in remote locations, such as start/stop panels, alarm tie-ins, and external temperature controls.

3. The entire electrical system shall be tested at the factory prior to shipping. All wiring shall comply with NEC requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions to receive equipment, for compliance with installation tolerances and other conditions affecting performance of air-handling units.

B. Examine roughing-in of steam, hydronic, condensate drainage piping, and electrical to verify actual locations of connections before installation.

C. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 USE OF AIR HANDLING UNITS DURING CONSTRUCTION

A. The installer of air handling units AHU-100,101,102, and 103 shall assume responsibility for operation, maintenance, and protection of each air handling unit during its use as a construction facility before Owner's acceptance, regardless of previously assigned responsibilities.

B. Air handling units AHU-100,101,102, and 103 may be used for temporary heat or ventilation providing the following conditions are met:

1. Start-up of the air handling unit has been performed by a factory trained representative or employee of the air handling unit manufacturer and start-up report has been submitted to the Architect.

2. Permanent electrical connections are complete.

3. All automatic temperature control work associated with the air handling units is complete and commissioned.

4. All filter banks are properly installed in the unit. Any air handling unit that is operated without the final filters in place, will require the entire supply duct system to be cleaned in accordance with specification section 15815 item 3.7 and NADCA (National Air Duct Cleaners Association) Standard – "Cleaning of Non-Porous Air Conveyance System Components" at no additional expense to the Owner.

a. During the duration of the construction, filter replacements may be required. Filters shall be changed at regular intervals to maintain a maximum of 1" S.P. across the pre-filters and a maximum of 1.5" across the final filters.

3.3 INSTALLATION

A. Install air-handling units level and plumb, according to manufacturer's written instructions.

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. Fill concrete inertia bases, after installing base frame, with **3000-psi (20.7-MPa)** concrete; trowel to a smooth finish.

1. Cast-in-place concrete materials and placement requirements are specified in Division 3.

3.4 STRUCTURAL STEEL SUPPORT

A. Coordinate size of structural steel supports with actual unit sizes provided. Coordinate the structural steel supports with the manufacturer's installation requirements.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. The Drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect condensate drain pans. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
3. Chilled-Water Piping: Conform to applicable requirements of Division 15 Section "Hydronic Piping." Connect to supply and return coil tappings as indicated on Contract Documents.
4. Steam and Condensate Piping: Conform to applicable requirements of Division 15 Section "Steam and Condensate Piping." Connect to supply and return coil tappings as indicated on Contract Documents.

B. Duct installation and connection requirements are specified in other Division 15 Sections. The Drawings indicate the general arrangement of ducts and duct accessories.

C. Electrical: Conform to applicable requirements of Division 16 Sections.

1. Connect disconnect switches to wiring systems and to ground. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
2. Temperature control wiring and interlock wiring is specified in Division 15 Section "HVAC Instrumentation and Controls".
3. All electrical and control wiring shall be connected to the air handling units with a 3'-0" long Sealtight flex connect.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

3.7 CLEANING

A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

1. Air handling units shall be cleaned after use for temporary heat and/or ventilation.

B. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean and wash down fan wheels, cabinets, and coils entering air face.

3.8 COMMISSIONING

A. Manufacturer's Field Inspection: Engage a factory-authorized service representative to perform the following:

1. Inspect field assembly of components and installation of indoor custom air-handling units including piping, ductwork, and electrical connections.
2. Prepare a written report on findings and recommended corrective actions.

B. Final Checks before Startup: Perform the following before startup:

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, ductwork, and electrical 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. Set outside-air and return-air mixing dampers to minimum outside-air setting.
5. Comb coil fins for parallel orientation.
6. Install clean filters.
7. Verify that manual and automatic volume control, and fire and smoke dampers in connected ductwork systems are in fully open position.

C. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for air-handling system testing, adjusting, and balancing.

3.9 DEMONSTRATION

A. Engage the services of a factory-authorized service representative to train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

1. Review data in the operation and maintenance manuals. Refer to Division 1 Section "Contract Closeout."
2. Schedule training with Owner, through Architect, with at least 7 days' advance notice.

END OF SECTION 15854

SECTION 15855 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

B. Related Sections include the following:

1. Division 10 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 15 Section "Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.
3. Division 15 Section "Testing, Adjusting, and Balancing" for balancing diffusers, registers, and grilles.

1.3 DEFINITIONS

A. Diffuser: Circular, square, rectangular, or laminar air flow panel, generally located in the ceiling and comprised of deflecting members and perforated panels, discharging supply air in various directions and planes and arranged to promote mixing of primary air with secondary room air.

B. Laminar Flow Diffuser : A perforated face , low velocity laminar flow air diffusion unit

C. Grille: A louvered or perforated covering for an opening in an air passage, which can be located in a sidewall, ceiling, or floor.

D. Register: A combination grille and damper assembly over an air opening.

1.4 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.
3. Assembly Drawing: For each type of air outlet and inlet; indicate materials and methods of assembly of components.

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, medical equipment and special moldings.
5. Duct access panels.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

1.5 QUALITY ASSURANCE

A. NFPA Compliance: Install diffusers, registers, and grilles according to NFPA 90A, "Standard for the Installation of Air-Conditioning and Ventilating 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 GRILLES AND REGISTERS

A. Double Deflection Supply Register: Drawing Designation S-7 through S-8.

1. Manufacturers:

a. Titus.
b. METALAIRE, Inc.; Metal Industries Inc.
c. Tuttle & Bailey.

2. Material: Steel.

3. Finish: Baked enamel, white.
4. Face Blade Arrangement: Adjustable horizontal spaced 3/4 inch (19 mm) apart.
5. Rear Blade Arrangement: Adjustable vertical spaced 3/4 inch (19 mm) apart.
6. Frame: 1-1/4 inches (32 mm) wide.
7. Mounting Frame: as noted on drawings
8. Damper Type: No damper required unless other wise noted
9. Accessories: Front blade gang operator is required on drawings.

B. Steel Fixed Face Grille/Register: Drawing Designation E/R-1 through E/R-6.

1. Manufacturers:

   a. Titus.
   b. METALAIRE, Inc.; Metal Industries Inc.
   c. Tuttle & Bailey.

2. Material: Steel.
3. Finish: Baked enamel, white.
4. Face Arrangement: Fixed blade, 45-degree deflection, 20-gage steel blades spaced at ¾-inches apart.
5. Frame: 1-1/4 inches (32 mm) wide.
6. Mounting: Countersunk screw.

C. Aluminum Fixed Face Grille/Register: Drawing Designation E/R-7 through E/R-11.

1. Manufacturers:

   a. Titus.
   b. METALAIRE, Inc.; Metal Industries Inc.
   c. Tuttle & Bailey.

2. Material: Aluminum.
3. Finish: Baked enamel, white.
4. Face Arrangement: Fixed blade, 45-degree deflection, 0.04-inch thick aluminum blades spaced at ¾-inches apart.
5. Frame: 1-1/4 inches (32 mm) wide.
6. Mounting: Countersunk screw.

D. Filter Return Grille: Drawing Designation E/R-12 through E/R-15.

1. Manufacturers:

   a. Titus.
   b. METALAIRE, Inc.; Metal Industries Inc.
   c. Tuttle & Bailey.

2. Material: Aluminum.

3. Finish: Baked enamel, white.
4. Face Arrangement: Adjustable horizontal spaced 3/4 inch (19 mm) apart.
5. Frame: 1 inches (32 mm) wide.
6. Mounting: Countersunk screw
7. Quarter turn twist fastener and hinge access.
8. Without filter.

2.42.3 CEILING DIFFUSER OUTLETS

A. Rectangular and Square Ceiling Diffusers: Drawing Designation S-1, S-2, S-3, S-4, S-5, S-6.

1. Manufacturers:

   a. Titus.
   b. METALAIRE, Inc.; Metal Industries Inc.
   c. Tuttle & Bailey.

2. Material: Steel.
3. Finish: Baked enamel, white.
4. Face Size: As scheduled on drawings.
5. Construction: Frames shall be assembled with corner inserts to ensure hairline seams. Cores shall be assembled with cross braces which interlock. Cores shall be equipped with spring loaded latches for core removal.
6. Blow Direction: 1, 2, 3, or 4 way as indicated on drawings.
7. Frame: As scheduled on drawings.
8. Accessories: Induction vanes and 3-inch deep square to round transition as indicated on Drawings.

2.4 LAMINAR FLOW SURGICAL PANELS

A. Rectangular and Square Ceiling Diffusers: Drawing Designation S-9 and S-10.
1. Types: Precision Air Products Lami-Vent Modules Model PAT
2. Materials: Extruded aluminum.
3. Construction: Perforated face with insulated plenum, diffusing plate,air valve mechanism, and panel frame.
4. Finish: Baked enamel, white.
5. Blow Direction: Laminar flow downwards.
6. Frame: To lay-in structural grid provided as an option with these diffusers.
7. Accessories: Provide structural ceiling grid. Grid shall accommodate the laminar flow diffusers and both the general and the operating room lighting. See architectural reflected ceiling plan for details.
8. The perforated face plate assembly shall be removable for cleaning of the entire diffuser. The face plate shall be retained to the framing through the use of safety chains.

2.5LAMINAR FLOW DIFFUSERS:

1.Manufacturers:

a.Precision Air Products Lami-Vent Modules Model PAT

2.Materials: Extruded aluminum.
3.Construction: Perforated face with insulated plenum, diffusing plate,air valve mechanism, and panel frame.
4.Finish: Off-white painted.
5.Blow Direction: Laminar flow downwards.
6.Frame: To lay-in structural grid provided as an option with these diffusers.
7.Accessories: Provide structural ceiling grid. Grid shall accommodate the laminar flow diffusers and both the general and the operating room lighting. See architectural reflected ceiling plan for details.

2.62.5 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."

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 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 15855

SECTION 15861 - AIR FILTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications.

1.3 SUBMITTALS

A. Comply with pertinent provisions of Section 01300 - "Submittals and Substitutions" and Section 15050 - "Basic Mechanical Requirements".

B. Product Data: Include dimensions; shipping, installed, and operating weights; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated. See drawings for equipment selection and installation information.

C. Shop Drawings: Include plans, elevations, sections, and details to illustrate component assemblies and attachments.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

D. Maintenance data for each type of filter and rack to include in the "Operating and Maintenance Manuals" specified in Section 01300 - "Submittals and Substitutions", Section 01700 - "Contract Closeout", and Section 15050 - "Basic Mechanical Requirements".

E. Coordination Drawings:

1. Framing 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:

2. Structural members to which filter assembly will be attached.
3. Sizes and locations of roof openings.

B. Welding certificates.

C. Maintenance Data: For each type of filter and rack to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 90A and NFPA 90B.

B. ASHRAE Compliance: Comply with provisions of ASHRAE 52.1 for method of testing and rating air-filter units.

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. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

E. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.3, "Structural Welding Code--Sheet Steel."

1.5 COORDINATION

A. Coordinate installation of roof curbs and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver inline duct fan and filter as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

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. Provide one complete set of filters for each filter bank.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Inline Duct Filter-Dryer lint trap:

a. XXXXXX

2. Throw Away Filters:

a. AAF.

b. Camfil Farr

3. Filter Gages:

a. Airguard Industries, Inc.
b. Dwyer Instruments Inc.

B. Filter Gages: Diaphragm type with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Diameter: 4-1/2 inches (115 mm).
2. Range: 0- to 4.0-inch wg (0 to 1000 Pa).
3. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

C. Static Pressure Tap: Provide a static pressure tap to allow for individual pressure drop reading across final filter section.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install filter assembly according to manufacturer's written instructions.

B. Position each filter unit with clearance for normal service and maintenance. Anchor filter assembly to roof .

C. Electrical wiring and connections are specified in Division 16 Sections.

D. Ground equipment.

1. 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.

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components, filter and filter-frame installation, and electrical wiring. Report results in writing.

B. HEPA Filters: Pressurize housing to a minimum of 3.0-inch wg (750 Pa) or to designed operating pressure, whichever is higher; and test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.

C. Equipment Startup Checks:

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. Verify lubrication for bearings and other moving parts.
6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

D. Starting Procedures:

1. Energize motor and adjust fan to indicated rpm.
2. Measure and record motor voltage and amperage.

E. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

F. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

G. Shut unit down and reconnect automatic temperature-control operators.

H. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

I. Replace fan and motor pulleys as required to achieve design airflow.

J. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

3.5 CLEANING

A. On completion of installation, internally clean fans and filter housing according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain inline duct fan and filter units.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15861

SECTION 15900 - HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. This specification outlines the requirements for the Charles St. Project and the interface of this project with the new Central Power Plant, Commission # 4675.

1.2 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Related Sections include the following:

1. Division 13 Section "Fire Alarm" for fire and smoke detectors mounted in HVAC systems and equipment.
2. Division 16 Section "Electrical Power Monitoring and Control."

1.3 DEFINITIONS

A. DDC: Direct-digital controls.

B. BAS: Building Automation System (interchangeable with EMS).

C. EMS: Energy Management System (interchangeable with BAS).

B.D. LAN: Local area network.

C.E. MS/TP: Master-slave/token-passing.

D.F. PICS: Protocol Implementation Conformance Statement.

1.4 SYSTEM DESCRIPTION

A. Control system consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multi-user, multitasking environment on token-passing network and programmed to control mechanical systems.

B. Control system includes the following:

1. One new operator workstation shall operate concurrently in the same network configuration as the existing Honeywell Building Management System, located in the Engineering Office or Central Power Plant, which has been expanded under the Central Power Plant Project, Commission #4675. This new operator workstation shall be located in the Charles St. Penthouse. The workstation shall provide control, monitoring, alarms, and all other control aspects of the new and existing control system. The existing system shall be upgraded to accommodate the new additional equipment. The two workstations shall communicate via new network of hardwired system network. Upgrades to license software agreements shall be made to accommodate the addition of this equipment. Project shall include dial up modem for remote dial up and system shall be capable of communicating remotely, and through local DDC panels of the existing network.

2. If integration between a new controls system and the existing Honeywell controls system is not possible the contractor shall provide two new head end mirrored workstations for all new control functions. These workstations shall be located at the Engineering Office/Central Power Plant and Charles St. Penthouse. A minimum number of data points must be communicated between the Honeywell and the new system to meet the sequences of operation for the new systems as outlined in the construction documents.

3. Provide a secure remote means of connection to access all building controls systems on the campus via the internet or a dial up modem for the Project Engineer. The modem shall be provided by the HVAC instrumentation and controls contractor. Access shall be provided for two TRO engineering staff members as soon as the head end workstations are in place and operational on the site. The access shall be password protected to allow the project engineers to only perform monitoring and trend logging capabilities for all control functions and trendable data points. Access to the system for the project engineer shall remain in place throughout the entire construction process and shall last for a period of one year beyond date of substantial completion .

1.5 SEQUENCE OF OPERATION

A. Refer to the Drawings for the Sequence of Operation.

1.6 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. Each control device labeled with setting or adjustable range of control.

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. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, differential pressure sensors, venturi/dp flow sensors and control devices.
2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
3. Details of control panel faces, including controls, instruments, and labeling.
4. Written description of sequence of operation.
5. Schedule of dampers including size, leakage, and flow characteristics.
6. Schedule air flow stations including operating range parameter and transmitter selection information
6.7. Schedule of valves including leakage and flow characteristics.
8. Schedule of venturi flow meter –differential pressure flow transmitters.
7.9. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
8.10. Listing of connected data points, including connected control unit and input device.
9.11. System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
10.12. As built drawings showing the locations of all control system fans, pumps, coils, dampers, valves, differential pressure sensors, venturi flow meter-differential pressure flow sensors and other control devices.
11.13. System configuration, showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.

C. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens. Provide printouts of software programming code required to meet the sequence of operation for each system. Include a legend defining each dependent and independent variable.
5. Software license required by and installed for DDC workstations and control systems.

D. Software Upgrade Kit: For Owner to use in modifying software to suit future power system revisions or monitoring and control revisions.

E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

F. Maintenance Data: For systems to include in maintenance manuals specified in Division 1. Include the following:

1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.

2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
5. Calibration records and list of set points.

G. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

H. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative or a certified installer of the automatic control system manufacturer for both installation and maintenance of units required for this Project.

B. Manufacturer Qualifications: A firm experienced in manufacturing automatic temperature-control systems similar to those 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 NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."

E. ASHRAE BACnet Statement: PICS for each DDC system component (panel, zone controller, field devices, and operator workstation) proposed.

F. Samples: For each color required, of each type of thermostat cover.

G. Year-2000 Compliant: Computer hardware and software shall be capable of accurately processing, providing, and receiving date data from, into, and between the twentieth and twenty-first centuries, including leap-year calculations.

H. Control System Review Conference: Meet with the Owner's and the Architect's representatives on approval of the controls systems proposal and procedures plan to develop a mutual understanding of the details. Ensure the participation of testing, adjusting, and balancing team members, equipment manufacturers' authorized service representatives, and other support personnel. Provide 7 days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:

a. Submittal distribution requirements.
b. Contract Documents examination report.
c. Technical Proposal.
d. Testing, adjusting, and balancing plan.
e. Work schedule and Project site access requirements.
f. Coordination and cooperation of trades and subcontractors.
g. Coordination of documentation and communication flow.
h. Commissioning plan and Project Engineer interface.

I.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

1.9 COORDINATION

A. Coordinate location of thermostats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 13 Section "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

C. Coordinate supply of conditioned electrical circuits for control units and operator workstation.

D. Coordinate vibration isolation of ATC compressor with Division 15 Section "Mechanical Vibration and Seismic Controls".

E. Coordinate seismic restraint of control panels with Division 15 Section "Mechanical Vibration and Seismic Controls".

F. Coordinate equipment with Division 16 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.

G. Coordinate equipment with Division 16 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

H. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

1.10 TECHNICAL PROPOSAL

A. Technical proposals shall be prepared in accordance with these specifications. Four (4) copies of the proposal shall be submitted with the bid. The technical proposal shall include the following minimal data and information.

1. Information on organizational capability to handle this project (management, personnel, manufacturing, single source responsibility, etc.)
2. Information on training program to demonstrate specification compliance.
3. System Configuration as Proposed:
   a. Describe system architecture including a schematic layout with location and type (model number) of all control panels.
   b. Describe system operation, hardware and software functions, description of software editors, and control techniques.
   c. Modularity.
   d. Provisions against obsolescence due to technological advancement. Provide list of project references.
   e. Provide hardware and software data sheets on interfaces with third party systems (e.g. chiller).
4. Technical data to support the information on the hardware configuration.
5. Detailed description of all operating, command, application and energy management software provided for this project.
6. A signed certificate stating the Contractor "has read the performance and functional requirements, understands them, and the technical proposal complies with all parts of the specification."
7. Line by line specification concordance statement.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. DDC Systems:

   a. Honeywell, Inc.; Home & Building Control
   c.b. Siemens Building Technology, Inc.

1.22.2 DDC EQUIPMENT

A. Operator Station: Microcomputer station with printer.

B. Workstation: IBM-compatible microcomputer with minimum configuration as follows:

1. Processor: Intel Pentium 4, 1.7 GHz.

2. Random-Access Memory: 256 MB RDRAM.
3. Cache Memory: 256 kB.
4. Graphics: Super video graphic adapter (SVGA), minimum 1280 x 1024 pixels, 32.0-MB NVIDIA video memory.
5. Monitor: 17 inches (432 mm), noninterlaced, color, with maximum 0.28-mm dot pitch.
6. Keyboard: QWERTY, 105 keys in ergonomic shape.
7. Floppy-Disk Drives: 1.44 MB.
8. Hard-Disk Drive: 60.0 GB.
9. CD-ROM Drive: 32x.
10. Mouse: Three button.
11. Modem: Autodial, internal, minimum 56 kBaud.
12. Tape Backup: Internal Zip-drive, 100 MB.
13. Operating System: Microsoft Windows 98 or later.
14. BACnet Conformance: Workstation shall support BACnet device and have minimum capabilities defined in PICS for the following areas:

    a. Network.
    b. Functional groups.
    c. Standard application services supported.
    d. Standard objects supported.

C. Printer: Color, ink-jet type as follows:

1. Print Head: 1440 x 1440 dpi photoquality color resolution.
2. Internal Memory Buffer: 32 kB.
3. Paper Handling: Minimum of 100 sheets.
4. Print Speed: Minimum of 8 ppm in black and 4 ppm in color.

D. Uninterrupted Power Supply (UPS): Provide an uninterrupted power supply for each workstation. UPS shall include the following features:

1. Duration: Capable of 13.6 hours of run time at 115 watts.
2. Voltage Output: 120 Volts.
3. Voltage Input: 120 Volts.
4. Input Connection: (1) NEMA 5-15P.
5. 5. Output Connections: (6) NEMA 5-15R.

E. Workstation Operator Interface Software.

1. Interface Description
    a. Operator workstation interface software shall minimize operator training through the use of English language prompting, on-line help, and industry standard PC application software. Interface software shall simultaneously communicate with up to 4 Building Level Networks and share data between any of the 4 networks. The software shall provide, as a minimum, the following functionality:
        1)
        2) Real-time graphical viewing and control of environment
        3) Scheduling and override of building operations

4) Collection and analysis of historical data
5) Point database editing, storage and downloading of controller databases.
6) Alarm reporting, routing, messaging, and acknowledgment
7) Display dynamic data trend plot.
   a) Must be able to run multiple plots simultaneously
   b) Each plot must be capable of supporting 10 pts/plot minimum
   c) Must be able to command points directly off dynamic trend plot application.
8) Definition and construction of dynamic color graphic displays.
9) Control program-editing including.
   a) Transfer trend data to 3rd party software
   b) Scheduling reports
   c) Operator Activity Log

b. Provide a graphical user interface, which shall minimize the use of keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection.

c. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BAS software shall run on a Windows© 32 bit operating system. Other Windows© applications shall run simultaneously with the BAS software.

   1) Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via user-sized windows. Operator shall be able to drag and drop information between applications, reducing the number of steps (i.e. Click on a point on the alarm screen and drag it to the dynamic trend graph application to initiate a dynamic trend).
   2) Dynamic color graphics and graphic control
   3) Alarm management, routing to designated locations, and customized messages
   4) Year in advance event and report scheduling
   5) Dynamic trend data definition and presentation
   6) Graphic definition and construction
   7) Program and point database editing on-line.

d. If the software is unable to display the listed types of displays at the same time, the BAS contractor shall provide multiple displays or workstations as required to do so.

e. Report and alarm printing shall be accomplished via Windows Print Manager, allowing use of network printers.

f. Operator specific password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password.

Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported).

g. Reports shall be generated on demand or via pre-defined schedule and directed to CRT displays, printers or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:

1) A general listing of all or selected points in the network
2) List of all points currently in alarm
3) List of all points currently in override status
4) List of all disabled points
5) List of all points currently locked out
6) List of user accounts and access levels
7) List all weekly schedules
8) List of holiday programming
9) List of limits and deadbands
10) Custom reports from 3rd party software
11) System diagnostic reports including, list of DDC panels on line and communicating, status of all DDC terminal unit device points.
12) List of programs

2. Scheduling and Overrides

a. Provide a calendar type format for simplification of time-of-day scheduling and overrides of building operations. Schedules reside in the PC workstation, DDC Controller, and HVAC Mechanical Equipment Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection or function key. Provide the following spreadsheet graphic types as a minimum:

1) Weekly schedules
2) Zone schedules, minimum of 200 unique zones
3) Scheduling for up to 365 days in advance
4) Schedule reports to print at PC.

3. Collection and Analysis of Historical Data

a. Provide trending capabilities that allow the user to monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.

b. Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups

of at least six points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred on-line to Microsoft Excel.

c. Provide additional functionality that allows the user to view real-time trend data on trend graph displays. A minimum of ten points may be graphed, regardless of whether they have been predefined for trending. The dynamic graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. Exact point values may be viewed and the graphs may be printed. Operator shall be able to command points directly on the trend plot by double clicking on the point.

4. Dynamic Color Graphics

a. Create individual color graphic floor plan displays and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems, condenser water systems and room level terminal units, provided by the BAS contractor as indicated in the point I/O schedule to optimize system performance, analysis and speed alarm recognition.

b. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of AutoCAD or scanned pictures for use in the system.

c. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.

d. Off the shelf graphic software, shall be provided to allow the user to add, modify or delete system graphic displays.

e. A clipart library of HVAC and automation symbols shall be provided including fans, valves, motors, pumps, dampers, AHU systems, standard ductwork and piping diagrams and symbols. The user shall have the ability to add custom symbols to the clipart library.

f. A dynamic display of the site-specific architecture showing status of controllers, PC workstations and networks shall be provided.

5. System Configuration & Definition

a. Network wide control strategies shall not be restricted to a single DDC Controller or HVAC Mechanical Equipment controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.

b. Provide automatic backup and restore of all DDC controller and HVAC Mechanical Equipment controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller or HVAC Mechanical Equipment Controller. Changes made at the DDC Controllers or HVAC Mechanical Equip-

ment Controllers shall be automatically uploaded to the workstation, ensuring system continuity.

c. System configuration, programming, editing, graphics generation shall be performed on-line. If programming and system back up must be done with the PC workstation off-line, the BAS contractor shall provide multiple operator workstations.

6. Alarm Management

a. Alarm Routing shall allow the user to send alarm notification to selected printers or PC location based on time of day, alarm severity, or point type.
b. Alarm Notification shall be provided via two alarm icons, to distinguish between routine, maintenance type alarms and critical alarms. These alarm icons shall be displayed when user is working in other Windows programs. The BAS alarm display screen shall be displayed when the user clicks on the alarm icon.
c. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.
d. Alarm messages shall be customizable for each point to display detailed instructions to the user regarding actions to take in the event of an alarm.

7. Workstation Communications

a. Provide automatic dial-up communications capabilities for remote buildings. Automatic dial-up communications shall include manual dial-out from the workstation to remote networks shall be accomplishable using only a mouse to select and request the desire remote connection.
b. Alarms shall automatically dial into the workstation for display at the terminal and for hard copy printout at the associated event printer.
c. Alarms shall, at the operator's option, dial into a stand-alone modem-printer to provide for real-time alarm printouts even when the workstation is off-line (such as when it is being used to run operator-selected 3rd party software).
d. Trend data shall be scheduled for automatic updating to the workstation at operator-selected times. The operator shall also have the option of manually collecting trend data at any time.

F. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source. Control units shall be capable of carrying out all control functions without a connection to the main operator workstations.

1. Units monitor or control each input/output point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator station.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.
b. Discrete/digital, analog, and pulse input/output.
c. Monitoring, controlling, or addressing data points.
d. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Local operator interface provides for download from or upload to mobile operator station.
4. BACnet Conformance: Reside on BACnet LAN in Ethernet IEEE 802.3, Class 3, minimum, with routers between LAN and other panels, with at least one communication port, and have minimum capabilities defined in PICS for the following areas:

a. Network.
b. Functional groups.
c. Standard application services supported.
d. Standard objects supported.

G. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source. Control units shall be capable of carrying out all control functions without a connection to the main operator workstations.

1. Units monitor or control each input/output point; process information; and download from or upload to operator station.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.
b. Discrete/digital, analog, and pulse input/output.
c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to mobile operator station.
4. BACnet Conformance: Reside on BACnet LAN using MS/TP, Class 2, minimum, with at least one communication port, and have minimum capabilities defined in PICS for the following areas:

a. Network.
b. Functional groups.
c. Standard application services supported.
d. Standard objects supported.

H. LANs: Capacity for a minimum of 10 workstations connected to multiuser, multitasking environment with concurrent capability to access DDC network or control units.

1. Media: Ethernet, peer-to-peer CMA/CD, operating at 10 MBps.

I. Software: Update to latest version of software at Project completion. Include and implement the following capabilities from the control units:

1. Units of Measure: Inch-pound and SI (metric).

2. Load Control Programs: Demand limiting, automatic time scheduling, start/stop time optimization, DDC with fine tuning, and trend logging.
3. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
4. Chiller Control Programs: Control function of condenser water reset, chilled-water reset, and equipment sequencing.
5. Programming Application Features: Include trend point, alarm messages, weekly scheduling, and interlocking.

2.3 CONTROL PANELS

A. Central (Master) Control Panels: Fully enclosed, steel-rack-type cabinet with locking doors or locking removable backs. Match finish of panels and provide multicolor graphic displays, schematically showing system being controlled.

B. Local Control Panels: Unitized cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels.

1. Fabricate panels of 0.06-inch- (1.5-mm-) thick, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish.
2. Panel-Mounted Equipment: Temperature and humidity controllers, relays, and automatic switches; except safety devices. Mount devices with adjustments accessible through front of panel.
3. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, including damper-positioning switches, changeover switches, thermometers, and gages.
4. Graphics: Color-coded graphic, laminated-plastic displays on doors, schematically showing system being controlled, with protective, clear plastic sheet bonded to entire door.

2.4 TIME CLOCKS

A. Solid-state, programmable time control with 4 separate programs; 24-hour battery carryover; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; and system fault alarm.

2.5 SENSORS

A. Electronic Sensors: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

1. Thermistor temperature sensors as follows:

a. Accuracy: Plus or minus 0.36 deg F (0.2 deg C) at calibration point.
b. Wire: Twisted, shielded-pair cable.

c. Insertion Elements in Ducts: Single point, 18 inches (46 cm) long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (1 sq. m).
d. Averaging Elements in Ducts: 72 inches (183 cm) long, flexible; use where prone to temperature stratification or where ducts are larger than 9 sq. ft. (1 sq. m); length as required.
e. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches (64 mm).
f. Room Sensors: Refer to Part 3 of this section for required accessories and locations required.
g. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

2. Humidity Sensors: Bulk polymer sensor element.

a. Accuracy: 5 percent full range with linear output.
b. Room Sensors: With locking cover matching room thermostats, span of 25 to 90 percent relative humidity.
c. Duct and Outside-Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

3. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.

a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
b. Output: 4 to 20 mA.
c. Building Static-Pressure Range: 0 to 0.25 inch wg (0 to 62 Pa).
d. Duct Static-Pressure Range: 0 to 5 inches wg (0 to 1243 Pa).

4. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.

B. Equipment operation sensors as follows:

1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inches wg (0 to 1243 Pa).
2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa).
3. Status Inputs for Electric Motors: Current-sensing relay with current transformers, adjustable and set to 175 percent of rated motor current.

C. Digital-to-Pneumatic Transducers: Convert plus or minus 12-V dc pulse-width-modulation outputs, or continuous proportional current or voltage to 0 to 20 psig (0 to 138 kPa).

D. Pneumatic Valve/Damper Position Indication: Potentiometer mounted in enclosure with adjustable crank-arm assembly connected to damper to transmit 0 to 100 percent valve/damper travel.

E. Electronic Valve/Damper Position Indication: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

F. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury or snap-acting type, with appropriate scale range and differential adjustment, with stainless-steel or bronze paddle. For chilled-water applications, provide vaporproof type.

G. Water-Flow Square Root Pressure Transmitters: Pressure-flow differential pressure transmitter to provide a 4 to 20 mA signal directly proportional to flow. This transmitter is to be used in conjunction with a calibrated venturi flow meter.

1. The flow transmitter shall have an operable range from 20 to 100% of flow rate.

2. No additional "block boxes" are required for use with this instrument.

3. Stable zero flow signal is achieved by electronically switching from a square root to a linear function at 20% of flow.

4. Output linear with input pressure for the range of 0 to 20% of flow (0% to 4% of input pressure).

5. No dead band.

6. Accuracy: +/- 0.25 of calibrated span for a range of 20% to 100% of flow(4% to 100% of input pressure). Includes combined effects of hysteresis, repeatability, and conformity of the square root function.

7. 5" to 750" H20 range. Range selected based on applicability.

8. Stability: +/- 0.25% of upper range limit for six months.

9. Temperature Effect: The total output effect, whether at zero or full scale, including zero and span errors: +/- 1.5% of upper range limit per 100 degrees F.

10. Static Pressure Effect: Zero error; +/- 0.25% of differential pressure upper range limit for 2000 PSI. Span error; correctable to +/-0.125% of reading per 1000 PSI. This is a systematic error, which can be calibrated out for a particular pressure before installation.

11. Damping: Time constant continuously adjustable between 0.2 and 1.0 seconds.

12. Static Pressure and Overpressure Limits: 0 PSIA to 2000 PSIG on either side without damage to the transmitter. Operate within specifications between static line pressure of ½ PSIA and 2000 PSIG, for silicone oil transmitters, and 10,000 PSIG proof pressure on the flanges.

13. NEMA 4X industrial enclosure.

14. Acceptable Manufacturers: Omega, OMEGA Engineering, Inc., model # series PX750-150(750)SQDI or approved equal.

H. Dewpoint Monitor: Provide dewpoint monitor as manufactured by Emseco – Newport Model.

2.6 THERMOSTATS

A. Combination Thermostat and Fan Switches: Line-voltage thermostat with two-, three-, or four-position, push-button or lever-operated fan switch.

1. Label switches "FAN ON-OFF," "FAN HIGH-LOW-OFF," "FAN HIGH-MED-LOW-OFF." Provide unit for mounting on two-gang switch box.

B. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch type, or equivalent solid-state type, with heat anticipator, integral manual on-off-auto selector switch.

1. Equip thermostats, which control electric heating loads directly, with off position on dial wired to break ungrounded conductors.
2. Dead Band: Maximum 2 deg F (1 deg C).

2.7 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
2. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
3. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).

B. Electronic Damper Actuators and Actuators for Valves Located Outside: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Valves: Size for torque required for valve close-off at maximum pump differential pressure.
2. Dampers: Size for running torque calculated as follows:

a. Parallel-Blade Damper with Edge Seals: 7 inch-pounds/sq. ft. (86.8 kg-cm/sq. m) of damper.
b. Opposed-Blade Damper with Edge Seals: 5 inch-pounds/sq. ft. (62 kg-cm/sq. m) of damper.

c. Parallel-Blade Damper without Edge Seals: 4 inch-pounds/sq. ft (49.6 kg-cm/sq. m) of damper.
d. Opposed-Blade Damper without Edge Seals: 3 inch-pounds/sq. ft. (37.2 kg-cm/sq. m) of damper.
e. Dampers with 2 to 3 Inches wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 FPM (5 to 13 m/s): Multiply the minimum full-stroke cycles above by 1.5.
f. Dampers with 3 to 4 Inches wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 FPM (13 to 15 m/s): Multiply the minimum full-stroke cycles above by 2.0.

3. Coupling: V-bolt and V-shaped, toothed cradle.
4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators.
6. Power Requirements (Two-Position Spring Return): 24-V ac.
7. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
8. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
9. Temperature Rating: Minus 22 to plus 122 deg F (minus 30 to plus 50 deg C).
10. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F (minus 30 to plus 121 deg C).
11. Run Time: 12 seconds open, 5 seconds closed.

C. Pneumatic Valve Operators: Rolling-diaphragm, spring-loaded, piston type with spring range as required and start-point adjustment and positioning relay. Operator shall maintain full shut-off at maximum pump differential pressure.

1. Control valves located in an interior location and over 1 inch shall be provided with pneumatic valve operators.

2.8 CONTROL VALVES

A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

B. Globe Valves NPS 2 (DN 50) and Smaller: Bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.

C. Globe Valves NPS 2-1/2 (DN 65) and Larger: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.

D. Hydronic system globe valves shall have the following characteristics:

1. Rating: Class 125 for service at 125 psig (862 kPa) and 250 deg F (121 deg C) operating conditions.
2. Internal Construction: Replaceable plugs and seats of stainless steel or brass.

a. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.

3. Sizing: 3-psig (21-kPa) maximum pressure drop at design flow rate.
4. Flow Characteristics: Two-way valves shall have equal percentage characteristics. Operators shall close valves against pump shutoff head.

E. Steam system globe valves shall have the following characteristics:

1. Rating: Class 125 for service at 125 psig (862 kPa) and 250 deg F (121 deg C) operating conditions.
2. Internal Construction: Replaceable plugs and seats of stainless steel.

a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.

3. Sizing: 10-psig (69-kPa) inlet pressure and 5-psig (35-kPa) pressure drop.
4. Sizing: Pressure drop across steam valve at a maximum flow of 80 percent of inlet pressure for low-pressure systems.
5. Flow Characteristics: Modified linear characteristics.

F. Butterfly Valves: 200-psig (1380-kPa), 150-psig (1035-kPa) maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.

1. Body Style: Lug.
2. Disc Type: Aluminum bronze.
3. Sizing: 1-psig (7-kPa) maximum pressure drop at design flow rate.

1.92.9 DAMPERS

A. Dampers: AMCA-rated, parallel or opposed-blade design as indicated on the Drawings; 0.1084-inch (2.8-mm) minimum, galvanized-steel frames with holes for duct mounting; damper blades shall not be less than 0.0635-inch (1.6-mm) galvanized steel with maximum blade width of 8 inches (203 mm).

1. Blades shall be secured to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
3. For standard applications, include optional closed-cell neoprene edging.
4. For low-leakage applications, use parallel- or opposed-blade design with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm per sq. ft. (51 L/s per sq. m) of damper area, at differential pressure of 4 inches wg (995 Pa) when

damper is being held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

2.10 ROOM PRESSURE CONTROLLERS

A. Manufacturers: Subject to compliance with requirements, provide room pressure controllers by the following:

1. TSI Inc. – PRESSURA Model 8630.

B. Pressure Sensor.

1. General: The pressure sensor shall consist of two velocity sensing elements mounted in-line with each other and a temperature compensating element. The velocity sensing elements shall be ceramic coated platinum RTD. Constant temperature anemometry shall be used to make the air velocity measurement.

   a. The pressure sensor shall be temperature compensated over a range of 55°F through 95°F.

2. Sensor Housing: The pressure sensor assembly shall consist of a molded plastic sensor, PVC tubing, intumescent rings, and a matching sensor housing.
3. Fire Rating: The pressure sensor assembly shall be ANSI/UL 1479 listed for "Fire Tests of Through Penetration Firestops". The unit shall be listed for a two hour fire rating.
4. Accuracy: The pressure sensor shall accurately measure room pressure from –0.20000 to +0.20000 inches water column. The sensor shall be capable of measuring down to 0.00015 inches water column. The sensor shall be bi-directional to determine the proper direction of negative pressure.
5. Cable: Provide a 6 conductor, 22 AWG cable with connector for wiring between the sensor and the pressure monitor.

C. Room Pressure Controller.

1. General: The room pressure controller shall measure, display and control room pressure. Controller, display, and configuration module shall be one integral unit.
2. Keypad: The keypad shall provide access to menu driven configuration options via and shall be a smooth spill-proof membrane switch.
3. Controller Housing: The controller housing shall be a molded plastic case. Case shall mount to a double gang electrical box.

   a. The controller shall have a sliding outer cover that protects the display and membrane switch. The cover shall have the capability of concealing the display with the alarm lights still visible.

4. Indicator Lights: Two indicator lights located on the front of the monitor shall indicate the following conditions:

a. Red – ALARM conditions.
b. Green – NORMAL or safe pressure conditions.

5. Display: Two line alphanumeric digital display indicating the measured room pressure in inches of water column. The display shall have a range of –0.20000 to +0.20000 with a resolution of 5 percent of reading and shall be updated every one-half second.

   a. The alphanumeric digital display shall indicate the actual room pressure (positive, negative, or no isolation), alarm status, menu options, diagnostics, and error messages. In normal operation, the display shall continuously scroll information about room status, pressure, and other configurable variables as applicable.

6. Alarm Set-points: The controller shall have high and low alarms for negative pressure and low and high alarms for positive pressure. Each alarm shall be capable of having a unique set-point.
7. Audible Alarm: The controller shall have an audible alarm that sounds when the room is in an alarm condition.
8. Test Button: A single test button on the face of the unit shall provide validation of set-points, alarm points, and unit self diagnostics.
9. Output: Linear pressure output shall be user selectable as either a 0-10 VDC or 4-20 mA, via the keypad.
10. Flow Station: An analog flow station shall be available for calculation of air changes per hour and to indicate when minimum volumes are not being maintained.
11. Communications: RS-485 communications with field selectable Modbus or Cimetrics communications protocol.
12. Wiring: Room pressure monitor wiring shall be to a terminal strip that plugs into the back of the monitor.

D. Damper Actuator.

1. Electric Actuator: The room pressure controller shall interface with an electric actuator with a control voltage of 0-10 volts. The control input current shall be less than 0.001 amps DC.
2. Enclosure: The damper actuator shall be enclosed in a metal case with a 7/8 inch knock-out for electrical wiring. Electrical connections shall be made to screw terminals.
3. Actuator Speed: The response time for 0 to 85 degrees of damper travel shall be 5 seconds or less.

   a. Actuator shall be capable of direct or reverse action.

4. Torque: 400 in-oz.
5. Overcurrent Protection: Provide overcurrent protection of 0.28 amps.

2.11 AIR FLOW MEASURING STATIONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Airflow Station Probes:
   a. Air Monitor Corporation - Volu-Probe/FI. (For fan inlet applications)
   b. Air Monitor Corporation - Volu-Probe/VS. (For inline duct mounted applications)

2. Airflow Station Flow Meter:
   a. Air Monitor Corporation – Type "M".

3. Electronic Differential Pressure Transmitter:
   a. Air Monitor Corporation – VELTRON Series 1000C.

B. Provide on the supply fan, air flow traverse probes factory mounted by the air handling unit manufacturer in the fan inlet capable of continuously measuring the fan capacity.

1. The fan inlet air flow traverse probes (two per inlet) shall contain multiple total and static pressure sensors placed at concentric area centers along the exterior surface of the cylindrical probe and internally connected to their respective averaging manifolds.
2. The fan inlet probe shall have dual end support swivel brackets suitable for mounting in the fan inlet bell and shall be of aluminum construction with hard anodized finish.
3. The probes shall be capable of producing steady, non-pulsating signals of standard and total static pressure without need for flow corrections or factors, with an accuracy of 3 percent of actual flow over a fan operating range of 6 to 1 turndown

C. Provide with the air flow traverse probes a NEMA 1 cabinet with air flow indication gauge and electronic differential pressure transmitter for the supply fan and the minimum outside air flow station. The cabinet shall be mounted in the piping vestibule of the air handling unit.

1. The air flow meter shall be mounted flush on the cabinet front door. The meter shall consist of a dual-scale, diaphragm-actuated differential pressure gauge. Gauge to read in cubic feet per minute (CFM) and in feet per minute (FPM). Meter to be complete with internal tubing, barb fitting for 1/4" O.D. tubing and furnished with a plastic data plate listing the system, air flow station number, fan number and design air volume.
2. The electronic differential pressure transmitter shall be capable of receiving signals of duct and reference static pressure and of amplifying and scaling the sensed differential pressure of inches W.C. into a 4-20mA DC or 0-5 VDC outlet signal linear to differential pressure. The differential pressure transmitter shall be capable of the following performance and application criteria:
3. Performance Characteristics Common to All Transmitters
   a. Reference Accuracy (Includes Non-Linearity, Hysteresis, and Non-Repeatability):
      1) +0.5 Percent of Span
   b. Output Signal:
      1) 4-20mA DC or 0-5 VCD Standard
   c. Power Supply:
      1) 12 to 40 DC unregulated: 2 wire, 4 to 20mA DC: 3 wire, 0 to 5 VDC.
   d. Integral Zeroing Means:
      1) 3-way zeroing valve with manual switch.
   e. Temperature Effect:
      1) +2.0 percent of full span from 40°F to 120°F

4. The transmitter shall not be damaged by over-pressurization up to 20 times greater than span and shall be furnished with a factory calibrated span and integral zeroing means. The transmitter shall be housed in a molded polyethylene (NEMA 12 steel) enclosure with external signal tubing, power and output signal connections.

D. Pneumatic tubing from the fan inlet probes to the gauge cabinet shall be factory installed by the air handling unit manufacturer. Pneumatic tubing shall be copper with maximum unsupported length of 36". Tubing shall be soldered or brazed, except at equipment and at shipping breaks where compression fittings shall be used. Tubing shall be pressure tested and purged with dry, oil-free compressed air before connections are made.

2.12 AIR SUPPLY

A. Control and Instrumentation Tubing: Type K, seamless copper tubing complying with ASTM B 88 (ASTM B 88M) or Type ACR, copper tubing complying with ASTM B 280.

1. Fittings: Cast-bronze solder fittings complying with ASME B16.18; or wrought-copper solder fittings complying with ASME B16.22, except forged-brass compression-type fittings at connections to equipment.
2. Joining Method: Soldered or brazed.

B. Control and Instrumentation Tubing: Virgin-polyethylene, flame-retardant, nonmetallic tubing complying with ASTM D 2737 with flame-retardant harness for multiple tubing.

1. Fittings: Compression or push-on polyethylene fittings.

C. Tank: ASME storage tank with drain test cock, automatic moisture removal trap, tank relief valve, and rubber-cork vibration isolation mounting pads.

D. Duplex Air Compressor: Capacity to supply compressed air to temperature-control system, but not smaller than the size indicated on the Drawings.

1. Adjustable electric contacts pressure control, set to start and stop both compressors at different pressures.
2. Electrical alternation set with motor starters and disconnect to operate compressors alternately or on time schedule.

E. Compressor Type: Reciprocating.

F. Size compressor and tank to operate compressor not more than 20 minutes during a 60-minute period.

G. Compressor Accessories: Low-resistance intake-air filter, and belt guards.

H. System Accessories: Air filter rated for 97 percent efficiency at rated airflow, and combination filter/pressure-reducing station or separate filter and pressure-reducing station.

I. Refrigerated Air Dryer: Self-contained, refrigerated air dryer complete with heat exchangers, moisture separator, internal wiring and piping, and with manual bypass valve.

1. Heat Exchangers: Air-to-refrigerant coils with centrifugal-type moisture separator and automatic trap assembly.
2. Refrigeration Unit: Hermetically sealed, operating to maintain dew point of 13 deg F (minus 11 deg C) at 20 psig (138 kPa), housed in steel cabinet with access door and panel.
3. Accessories: Air-inlet temperature gage, air-inlet pressure gage, on-off switch, high-temperature light, power-on light, refrigerant gage on back, air-outlet temperature gage, air-outlet pressure gage, and with contacts for remote indication of power status and high-temperature alarm.

J. Desiccant Dryer: Obtains dew point in pneumatic air piping between compressor and tank at least 15 deg F (minus 9 deg C) below inlet-air dew point at design conditions.

K. Pressure Gages: Black letters on white background, 2-1/2-inch (64-mm) diameter, flush or surface mounted, with front calibration screw to match sensor, in appropriate units.

L. Instrument Pressure Gages: Black letters on white background, 1-1/2-inch (38-mm) diameter, stem mounted, with suitable dial range.

M. Diaphragm Control and Instrument Valves: 1/4-inch (6-mm) forged-brass body with reinforced polytetrafluoroethylene diaphragm, stainless-steel spring, and color-coded phenolic handle.

N. Gage Cocks: Tee or level handle, bronze, rated for 125 psig (862 kPa).

O. Relays: For summing, reversing, amplifying, highest or lowest pressure selection, with adjustable input/output ratio.

P. Switches: With indicating plates, accessible adjustment, calibrated and marked.

Q. Pressure Regulators: Zinc or aluminum castings with elastomeric diaphragm, balanced construction to automatically prevent pressure build-up, and producing flat reduced-pressure curve.

R. Particle Filters: Zinc or aluminum castings with 97 percent filtration efficiency at rated airflow, quick-disconnect service devices, and aluminum or plastic bowl with metal guard and manual drain cock.

S. Combination Filter/Regulators: Zinc or aluminum castings with elastomeric diaphragm, balanced construction to automatically prevent pressure build-up, and producing flat reduced-pressure curve; with threaded pipe connections, quick-disconnect service devices, and aluminum or plastic bowl with metal guard and manual drain cock.

T. Airborne Oil Filter: Filtration efficiency of 99.9 percent for particles of 0.025 micrometer or larger particles of airborne lubricating oil.

U. Pressure Relief Valves: ASME rated and labeled.

1. High Pressure: Size for installed capacity.
2. Low Pressure: Size for installed capacity of pressure regulators and set at 20 percent above low pressure.

V. Pressure-Reducing Stations: Two parallel pressure regulators.

2.13 CONTROL CABLE

A. Electronic and Fiber-Optic Cable for Control Wiring: As specified in Division 16 Section "Control/Signal Transmission Media."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

B. Verify that duct-, pipe-, and equipment-mounted devices and wiring and pneumatic piping are installed before proceeding with installation.

3.2 INSTALLATION

A. Install equipment level and plumb in accessible locations.

B. Install software in control units and operator workstation. Implement all features of programs to specified requirements and as appropriate to sequence of operation.

C. Connect and configure equipment and software to achieve sequence of operation specified.

D. Mount compressor and tank unit on vibration isolators according to Division 15 Section "Mechanical Vibration Controls and Seismic Restraints." Isolate air supply with wire-braid-reinforced rubber hose. Secure and anchor according to manufacturer's written instructions and seismic control requirements.

1. Pipe manual and automatic drains to nearest floor drain.
2. Supply instrument air from compressor units through filter, pressure-reducing valve, and pressure relief valve, with pressure gages and shutoff and bypass valves.

E. Verify location of thermostats, and other exposed control sensors with plans and room details before installation. Locate all 60 inches (1524 mm) above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

F. Install automatic dampers according to Division 15 Section "Duct Accessories."

G. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

H. Install labels and nameplates to identify control components according to Division 15 Section "Basic Mechanical Materials and Methods."

I. Install labels and nameplates to identify control components according to Division 15 Section "Mechanical Identification."

J. Install hydronic instrument wells, valves, and other accessories according to Division 15 Section "Hydronic Piping."

K. Install duct volume-control dampers according to Division 15 Sections specifying air ducts.

L. Install electronic and fiber-optic cables according to Division 16 Section "Control/Signal Transmission Media."

M. Provide room sensors with programmable setpoint adjustment via portable workstation and adjustable temperature range (via slider mounted on sensor) in the following locations:

1. Post-partum rooms.
4.2. C-Section Rooms.
3. NICU Rooms.
5.4. LDR Rooms.
6.5. Nursery Rooms.
7.6. Nurses Stations.
8.7. All Diagnostic Rooms.
9.8. Isolation Rooms.
10.9. Lounges/Locker Rooms.
11.10. Offices.
12.11. Electric and Telecommunications closets.
13.12. Storage Areas.
14.13. Mechanical Spaces.
15.14. Shell Spaces.
17.15. Classrooms.

N. Provide room sensors in the following locations:

1. Entrances.
2. Public areas.
3. Atrium.
4. Elevator machine rooms.
5. Normal and Emeregency Power Substation Rooms.
6. Main Telecom room.

O. Provide duct and humidity sensors in the following locations: The sensing function of these devices works in conjunction with the adjustable wall thermostat provided in the room.

1. Isolation rooms
2. C-section Rooms
3. Nursery Suites,

3.3 PNEUMATIC PIPING INSTALLATION

A. Install piping in mechanical equipment rooms inside mechanical equipment enclosures, in pipe chases, or suspended ceilings with easy access.

1. Install copper tubing with maximum unsupported length of 36 inches (914 mm), for tubing exposed to view.
2. Install copper tubing for tubing required for smoke control systems and smoke dampers.
3. Install polyethylene tubing for applications in concealed locations.
4. All control tubing shall be supported independently from the structure.

B. Install terminal single-line connections, less than 18 inches (450 mm) in length, with copper or polyethylene tubing run inside flexible steel protection.

C. Purge tubing with dry, oil-free compressed air before connecting control instruments.

1. Bridge cabinets and doors with flexible connections fastened along hinge side; protect against abrasion. Tie and support tubing.

D. Number-code or color-code control air piping for future identification and service of control system, except local individual room control tubing.

E. Pressure Gages or Test Plugs: Install on branch lines at each receiver controller and on signal lines at each transmitter, except individual room controllers.

3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. A hard wired connection is required between the secondary chilled water differential pressure sensor in the Charles St. Penthouse and the head end computer, located in the new Central Power Plant for control of the secondary pump VFD controller for real-time signal and response control.

A.B. Install raceways, boxes, and cabinets according to Division 16 Section "Raceways and Boxes."

B.C. Install building wire and cable according to Division 16 Section "Conductors and Cables."

C.D. Install signal and communication cable according to Division 16 Section "Control/Signal Transmission Media."

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install exposed cable in electrical metallic tubing.

3. Install concealed cable in electrical metallic tubing or provide plenum rated cable without conduit.
4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

D.E. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E.F. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to machine to allow service and maintenance.

B. Ground equipment.

1. 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 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
4. Pressure test control air piping at 30 psig (207 kPa) or 1.5 times the operating pressure for 24 hours, with maximum 5-psig (35-kPa) loss.
5. Pressure test high-pressure control air piping at 150 psig (1034 kPa) and low-pressure control air piping at 30 psig (207 kPa) for 2 hours, with maximum 1-psig (7-kPa) loss.

B. Engage a factory-authorized service representative to perform startup service.

C. Replace damaged or malfunctioning controls and equipment.

1. Start, test, and adjust control systems.
2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

D. Verify DDC as follows:

1. Verify software including automatic restart, control sequences, scheduling, reset controls, and occupied/unoccupied cycles.
2. Verify operation of operator workstation.
3. Verify local control units including self-diagnostics.

3.7 ON SITE - DEMONSTRATION AND TRAINING

A. Engage a factory-authorized instructor to train Owner's maintenance personnel to adjust, operate, and maintain control systems and components. This training shall not be part of the commissioning process. On-site training shall include a minimum of 40 hours for Owner designated operating personnel and shall take place during normal working hours of 8:00 a.m. to 4:30 p.m. The owner-designated personnel shall include two supervisors, five foremen, three daytime and two nightshift HVAC mechanics for a total of twelve trainees. Each trainee shall receive a student binder containing product specific training modules for the system installed.

B. Perform a walk through of the job to locate control components, operator workstations, and all peripherals.

C. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.

D. Provide operator training on data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs.

E. Delete subparagraph above or below depending on which Section is retained in Division 1.

F. Review "as-built" control system drawings and data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."

G. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.8 OFF - SITE ADDITIONAL DEMONSTRATION AND TRAINING

A. Provide additional training off-site at a regional, district, or national training facility to six Owner designated personnel. Training shall provide a comprehensive factory authorized technician level of understanding of all installed hardware and software.

B. Off-Site training shall provide continuing education units (CEUs) upon successful completion of the course. The courses shall be scheduled over a two-year period and shall include six (CEUs) for each owner representative.

C. Course tuition for the training classes shall be the responsibility of the HVAC controls contractor. Travel and lodging costs will be the responsibility of the Owner.

3.9 MAINTENANCE CONTRACT

A. The HVAC controls contractor shall include a one year maintenance contract after date of substantial completion for all control system components with no binding on warranty work by others.

3.10 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

END OF SECTION 15900

SECTION 15990 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes testing, adjusting, and balancing HVAC systems to produce design objectives, including the following:

1. Providing pre-balance testing of air and hydronic flows and equipment performance reports to establish benchmarks of existing systems for re-commissioning efforts of any systems tapped into prior to any demolition work.

2. Balancing airflow and water flow within distribution systems, including submains, branches, and terminals, to indicated quantities according to specified tolerances.
3. Adjusting total HVAC systems to provide indicated quantities.
4. Measuring electrical performance of HVAC equipment.
5. Setting quantitative performance of HVAC equipment.
6. Verifying that automatic control devices are functioning properly.
7. Measuring sound and vibration.
8. Reporting results of the activities and procedures specified in this Section.
9. Work with HVAC Instrumentation and Controls contractor to verify and calibrate all flow measuring devices.
10. **Hydronic testing for new and existing systems by the Water Balance Contractor, shall be performed with an ultrasonic flowmeter by "Controlotron System, Uniflow Storm-meter, Model#1010wdpi. This shall be used to validate all other flow devices.**

B. Related Sections include the following:

1. Testing and adjusting requirements unique to particular systems and equipment are included in the Sections that specify those systems and equipment.
2. Field quality-control testing to verify that workmanship quality for system and equipment installation is specified in system and equipment Sections.

1.3 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to design quantities.

C. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

D. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

E. Report Forms: Test data sheets for recording test data in logical order.

F. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

G. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

H. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

I. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

J. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

K. Test: A procedure to determine quantitative performance of a system or equipment.

L. Testing, Adjusting, and Balancing Agent: The entity responsible for performing and reporting the testing, adjusting, and balancing procedures.

M. AABC: Associated Air Balance Council.

N. AMCA: Air Movement and Control Association.

O. NEBB: National Environmental Balancing Bureau.

P. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

1.4 SUBMITTALS

A. Quality-Assurance Submittals: Within 30 days from the Contractor's Notice to Proceed, submit 2 copies of evidence that the testing, adjusting, and balancing Agent and this Project's testing, adjusting, and balancing team members meet the qualifications specified in the "Quality Assurance" Article below.

B. Contract Documents Examination Report: Within 45 days from the Contractor's Notice to Proceed, submit 2 copies of the Contract Documents review report as specified in Part 3 of this Section.

C. Strategies and Procedures Plan: Within 60 days from the Contractor's Notice to Proceed, submit 2 copies of the testing, adjusting, and balancing strategies and step-by-step procedures as specified in Part 3 "Preparation" Article below. Include a complete set of report forms intended for use on this Project.

D. Certified Testing, Adjusting, and Balancing Reports: Submit 2 copies of reports prepared, as specified in this Section, on approved forms certified by the testing, adjusting, and balancing Agent.

E. Sample Report Forms: Submit 2 sets of sample testing, adjusting, and balancing report forms.

1.5 QUALITY ASSURANCE

A. Agent Qualifications: Engage an independent testing, adjusting, and balancing agent certified by either AABC or NEBB. Agent shall be under the auspices of the Construction Mananger.

B. Testing, Adjusting, and Balancing Conference: Meet with the Owner's and the Architect's representatives on approval of the testing, adjusting, and balancing strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of testing, adjusting, and balancing team members, equipment manufacturers' authorized service representatives, HVAC controls Installer, and other support personnel. Provide 7 days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:

   a. Submittal distribution requirements.
   b. Contract Documents examination report.
   c. Testing, adjusting, and balancing plan.
   d. Work schedule and Project site access requirements.
   e. Coordination and cooperation of trades and subcontractors.
   f. Coordination of documentation and communication flow.

C. Certification of Testing, Adjusting, and Balancing Reports: Certify the testing, adjusting, and balancing field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified testing, adjusting, and balancing reports.
2. Certify that the testing, adjusting, and balancing team complied with the approved testing, adjusting, and balancing plan and the procedures specified and referenced in this Specification.

D. Testing, Adjusting, and Balancing Reports: Use standard forms from SMACNA "HVAC Systems--Testing, Adjusting, and Balancing." Include in the report system layout drawings identifying terminal and duct traverse locations.

E. Instrumentation Type, Quantity, and Accuracy: As described in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification." Additionally, Hydronic testing for new and existing systems by the Water Balance Contractor, shall be performed with an ultrasonic flowmeter by "Controlotron System, Uniflow Storm-meter, Model#1010wdpi. This shall be used to validate all other flow devices.

F. Instrumentation Calibration: Calibrate instruments at least every 6 months or more frequently if required by the instrument manufacturer.

1.6 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 testing, adjusting, and balancing activities.

B. Notice: Provide 7 days' advance notice for each test. Include scheduled test dates and times.

C. Perform testing, adjusting, and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS

A. **Hydronic testing by the Water Balance Contractor, shall be performed with an ultrasonic flowmeter by "Controlotron System, Uniflow Storm-meter, Model#1010wdpi. This shall be used to validate all other flow devices.**

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, and balancing of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of the Contract.

2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine project record documents described in Division 1 Section "Project Record Documents."

D. Examine equipment performance data, including fan and pump curves. 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. Calculate system effect factors to reduce the performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

E. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.

F. Examine system and equipment test reports.

G. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

H. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

I. Examine air-handling equipment to ensure clean filters have been installed, 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 mixing boxes, to verify that they are accessible and their controls are connected and functioning.

K. Examine Isolation Rooms, C-Section Rooms, Special Nurseries and any other rooms where room pressure control (positive or negative) is required to verify that they are airtight and that monitoring controls are calibrated. Verify that pipe penetrations and other holes are sealed.

L. Examine strainers for clean screens and proper perforations.

M. Examine 3-way valves for proper installation for their intended function of diverting or mixing fluid flows.

N. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

O. Examine open-piping-system pumps to ensure absence of entrained air in the suction piping.

P. Examine equipment for installation and for properly operating safety interlocks and controls.

Q. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices operate by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers mixing boxes and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including 2-way valves and 3-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to design values.

R. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

3.2 PREPARATION

A. Prepare a testing, adjusting, and balancing plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness 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 design conditions for system operations can be met.

3.3 GENERAL TESTING AND BALANCING PROCEDURES

A. Perform testing and balancing procedures on each system according to the procedures contained in SMACNA's "HVAC Systems--Testing, Adjusting, and Balancing" and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the insulation Specifications for this Project.

C. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.4 FUNDAMENTAL AIR SYSTEMS' BALANCING PROCEDURES

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 the airflow patterns from the outside-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. Lifting of condensate returns is not acceptable. All condensate returns shall be by gravity.

K. Check for proper sealing of air-handling unit components.

3.5 CONSTANT-VOLUME AIR SYSTEMS' BALANCING PROCEDURES

A. The procedures in this Article apply to constant-volume supply-, return-, and exhaust-air systems. Additional procedures are required for variable-air-volume supply-air systems and proc-

ess return and exhaust-air systems. These additional procedures are specified in other articles in this Section.

B. Adjust fans to deliver total design airflows within the maximum allowable rpm listed by the fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:

a. Measure outlet static pressure as far downstream from the fan as practicable 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 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.

2. Measure static pressure across each air-handling unit component.

a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps under final balanced conditions.
4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
5. Adjust fan speed higher or lower than design with the approval of the Architect. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
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 no overload will occur. Measure amperage in full cooling, full heating, and economizer modes to determine the maximum required brake horsepower.

C. Adjust volume dampers for main duct, submain ducts, and major branch ducts to design airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

a. Where sufficient space in submains 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. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submains and branch ducts to design airflows within specified tolerances.

D. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or the outlet manufacturer's written instructions and calculating factors.

E. Adjust terminal outlets and inlets for each space to design airflows within specified tolerances of design values. Make adjustments using volume dampers rather than extractors and the dampers at the air terminals.

1. Adjust each outlet in the same room or space to within specified tolerances of design 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 VARIABLE-AIR-VOLUME SYSTEMS' ADDITIONAL PROCEDURES

A. Compensating for Diversity: For all systems; When the total airflow of all terminal units is more than the fan design airflow volume, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the design airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Supply Air Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set air handling unit outside-air dampers at minimum, and 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 duct losses.
3. Measure total system airflow by a duct traverse at a location in the supply duct as close to the main ductwork shaft as possible. Adjust to within 10 percent of design airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use the terminal unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units 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 as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets 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 adequate static pressure is maintained at the most critical unit.
8. Record the final fan and variable frequency drive performance data.

C. Pressure-Independent, Variable-Air-Volume Return Air Systems: After the fan systems have been adjusted, adjust the variable-air-volume return air terminal boxes as follows:

1. This work shall be completed after the supply air system has been balanced. This step shall be completed in conjunction with the balancing of the constant volume portion of the return air systems' balancing.

2. Set air handling unit outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.
3. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use the terminal unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
4. 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 as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

5. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

6. Record the final fan and variable frequency drive performance data.

D. Pressure-Independent, Variable-Air-Volume Infectious Exhaust Air System: After the fan systems have been adjusted, adjust the variable-air-volume exhaust air terminal boxes as follows:
1. This work shall be completed after all other air systems in the building have been balanced and are under normal ATC control as outlined in the Construction Documents. The balancer shall be responsible for inspecting the condition of the air-tightness of each isolation room. The balancer shall submit a report to the architect outlining any deficiencies found in the room construction that are detrimental to achieving the appropriate air-tightness.
2. Select the terminal unit that is most critical to the exhaust-fan airflows and static pressures. Measure exhaust system static pressure. Adjust system static pressure setpoint 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 inlet duct losses. The minimum static pressure setpoint shall not be more positive that –0.5" w.g.".

3. Measure total system airflow. Adjust to within 10 percent of design airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use the terminal unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air inlets upstream from terminal units 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 inlets for a proportional reduction in airflow as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave the inlets balanced for maximum airflow.

6. Remeasure the exhaust airflow to the fan while operating at maximum exhaust airflow. Adjust the fan and balance the exhaust-air ducts and inlets as described for constant-volume air systems.

7. Place the air terminals under their normal control sequences and record the airflow (CFM) of supply air and exhaust air into and out of each room served by the system. Verify the negative pressure reading of each isolation room pressure controller/monitor by measuring the pressure difference across the door with the door shut. If errors between the measured reading and the reading from the pressure controller/monitor are outside of acceptable tolerances, follow the pressure controller/monitor manufacturer's instructions on re-calibrating the controller/monitor. Once calibrated record the final pressure differential across each closed room door.

8. With fan system and room under normal ATC control open isolation room door for 10 seconds and verify that room differential pressure does not rise above negative 0.01" w.g.

9. Record the final fan and variable frequency drive performance data for each setting. (Maximum airflow, minimum airflow, and System under ATC control airflow.)

3.7 FUNDAMENTAL PROCEDURES FOR HYDRONIC SYSTEMS

A. **Hydronic testing by the Water Balance Contractor, shall be performed with a ultrasonic flowmeter by "Controlotron System, Uniflow Storm-meter, Model#1010wdpi. This shall be used to validate all other flow devices.**

B. 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 approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

C. Prepare schematic diagrams of systems' "as-built" piping layouts.

D. 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 expansion tank liquid level.
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 design 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 HYDRONIC SYSTEMS' BALANCING PROCEDURES

A. Determine 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. Verify with the pump manufacturer that this will not damage pump. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on the manufacturer's pump curve at zero flow and confirm that the pump has the intended impeller size.
2. Check system resistance. With all valves open, read pressure differential across the pump and mark the pump manufacturer's head-capacity curve. Adjust pump discharge valve until design water flow is achieved.
3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on the 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 5 percent of design.

B. Set calibrated balancing valves, if installed, at calculated presettings.

C. 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.

D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than design flow.

E. Adjust balancing stations to within specified tolerances of design flow rate as follows:

1. Determine the balancing station with the highest percentage over design flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over design flow and proceeding to the station with the lowest percentage over design flow.
3. Record settings and mark balancing devices.

F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures, including outdoor-air temperature.

G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.9 VARIABLE-FLOW HYDRONIC SYSTEMS' ADDITIONAL PROCEDURES

A. Balance systems with automatic 2-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.10 PRIMARY-SECONDARY-FLOW HYDRONIC SYSTEMS' ADDITIONAL PROCEDURES

A. Balance the primary system crossover flow first, then balance the secondary system. The primary chilled water system has been or will be constructed under a separate contract, but the new secondary requirements, necessitate adjustments to the primary system for proper system balance.

3.11 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. Check the setting and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves.

E. Record safety valve settings.

F. Verify operation of steam traps.

3.12 MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer, model, and serial numbers.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating if high-efficiency motor.
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 for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.13 AIR COOLED CONDENSERS

A. Verify proper rotation of fans and measure entering- and leaving-air temperatures and entering and leaving water temperatures.

3.14 HEAT-TRANSFER COILS

A. Water Coils: Measure the following data for each coil:

1. Entering- and leaving-water temperatures.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperatures of entering and leaving air.
5. Wet-bulb temperatures of entering and leaving air for cooling coils designed for less than 7500 cfm (3540 L/s).
6. Airflow.
7. Air pressure drop.

B. Electric-Heating Coils: Measure the following data for each coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperatures at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kW at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Steam Coils: Measure the following data for each coil:

1. Entering steam pressure after the control valve.
2. Dry-bulb temperatures of entering and leaving air.
3. Airflow.
4. Air pressure drop.

3.15 TEMPERATURE TESTING

A. During testing, adjusting, and balancing, report need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of 2 successive 8-hour days, in a representative sample of 6 separately controlled zones, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.16 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. Verify operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Verify free travel and proper operation of control devices such as damper and valve operators.

F. Verify 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. Confirm interaction of electrically operated switch transducers.

H. Confirm interaction of interlock and lockout systems.

I. Verify main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine if the system operates on a grounded or non-grounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.17 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans: Plus 5 to plus 10 percent.
2. Supply Air Outlets: Minus 5 percent to plus 5 percent.
3. Return Air Inlets: 0 to plus 10 percent.
4. Exhaust Air Inlets: 0 to minus 10 percent.
5. Heating-Water Flow Rate: 0 to plus 5 percent.
6. Cooling Water Flow Rate: 0 to plus 5 percent.
7. Isolation Rooms Negative pressure: 0 to minus 10% pressure (inches water gauge).
8. C-Section Room pressure: 0 to plus 15% pressure (inches water gauge).

9. Nursery Suite: 0 to plus 10% pressure (inches water gauge).

3.18 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article above, 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.

B. Pre-Balance report for existing conditions as specified on contract documents prior to demolition of the effected systems.

C. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.19 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in 3-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of the instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to the 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, but do not include approved Shop Drawings and Product Data.

D. General Report Data: In addition to the form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of testing, adjusting, and balancing Agent.
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 testing, adjusting, and balancing Agent who certifies the report.
10. Summary of contents, including the following:

    a. Design versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

11. Nomenclature sheets for each item of equipment.
12. Data for terminal units, including manufacturer, type size, and fittings.
13. Notes to explain why certain final data in the body of reports vary from design values.
14. Test conditions for fans and pump performance forms, including the following:

    a. Settings for outside-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Fan drive settings, including settings and percentage of maximum pitch diameter.
    e. Settings for supply-air, static-pressure controller.
    f. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present with single-line diagrams and include the following:

1. Quantities of outside, 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.

F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data: Include the following:

    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 (mm), and bore.
    i. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).
    j. Number of belts, make, and size.
    k. Number of filters, type, and size.

2. Motor Data: Include the following:

   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 (mm), and bore.
   f. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).

3. Test Data: Include design and actual values for the following:

   a. Total airflow rate in cfm (L/s).
   b. Total system static pressure in inches wg (Pa).
   c. Fan rpm.
   d. Discharge static pressure in inches wg (Pa).
   e. Filter static-pressure differential in inches wg (Pa).
   f. Preheat coil static-pressure differential in inches wg (Pa).
   g. Cooling coil static-pressure differential in inches wg (Pa).
   h. Outside airflow in cfm (L/s).
   i. Return airflow in cfm (L/s).
   j. Outside-air damper position.
   k. Return-air damper position.

G. Apparatus-Coil Test Reports: For apparatus coils, include the following:

1. Coil Data: Include the following:

   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch (mm o.c.).
   f. Make and model number.
   g. Face area in sq. ft. (sq. m).
   h. Tube size in NPS (DN).
   i. Tube and fin materials.
   j. Circuiting arrangement.

2. Test Data: Include design and actual values for the following:

   a. Airflow rate in cfm (L/s).
   b. Average face velocity in fpm (m/s).
   c. Air pressure drop in inches wg (Pa).
   d. Outside-air, wet- and dry-bulb temperatures in deg F (deg C).
   e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
   f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
   g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
   h. Water flow rate in gpm (L/s).

i. Water pressure differential in feet of head or psig (kPa).
j. Entering-water temperature in deg F (deg C).
k. Leaving-water temperature in deg F (deg C).
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig (kPa).
n. Refrigerant suction temperature in deg F (deg C).
o. Inlet steam pressure in psig (kPa).

H. Electric-Coil Test Reports: For electric coils installed in packaged rooftop units, include the following:

1. Unit Data: Include the following:

a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btuh (kW).
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Airflow rate in cfm (L/s).
i. Face area in sq. ft. (sq. m).
j. Minimum face velocity in fpm (m/s).

2. Test Data: Include design and actual values for the following:

a. Heat output in Btuh (kW).
b. Airflow rate in cfm (L/s).
c. Air velocity in fpm (m/s).
d. Entering-air temperature in deg F (deg C).
e. Leaving-air temperature in deg F (deg C).
f. Voltage at each connection.
g. Amperage for each phase.

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data: Include the following:

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 (mm), and bore.
h. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).

2. Motor Data: Include the following:

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 (mm), and bore.
f. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).
g. Number of belts, make, and size.

3. Test Data: Include design and actual values for the following:

a. Total airflow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).
c. Fan rpm.
d. Discharge static pressure in inches wg (Pa).
e. Suction static pressure in inches wg (Pa).

J. 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: Include the following:

a. System and air-handling unit number.
b. Location and zone.
c. Traverse air temperature in deg F (deg C).
d. Duct static pressure in inches wg (Pa).
e. Duct size in inches (mm).
f. Duct area in sq. ft. ((sq. m)).
g. Design airflow rate in cfm (L/s).
h. Design velocity in fpm (m/s).
i. Actual airflow rate in cfm (L/s).
j. Actual average velocity in fpm (m/s).
k. Barometric pressure in psig (Pa).

K. Air-Terminal-Device Reports: For terminal units, include the following:

1. Unit Data: Include the following:

a. System and air-handling unit identification.
b. Location and zone.
c. Test apparatus used.
d. Area served.
e. Air-terminal-device make.
f. Air-terminal-device number from system diagram.
g. Air-terminal-device type and model number.
h. Air-terminal-device size.
i. Air-terminal-device effective area in sq. ft. ((sq. m)).

2. Test Data: Include design and actual values for the following:

a. Airflow rate in cfm (L/s).
b. Air velocity in fpm (m/s).
c. Preliminary airflow rate as needed in cfm (L/s).
d. Preliminary velocity as needed in fpm (m/s).
e. Final airflow rate in cfm (L/s).
f. Final velocity in fpm (m/s).
g. Space temperature in deg F (deg C).

L. Infectious Isolation Rooms:

1. Test Data: Include design and actual values for the following:

a. Airflow rate into and out of room cfm (L/s).
b. Differential Pressure Across doorway with door closed for more than one minute inches w.g..
c. Differential Pressure Across doorway with door open for ten seconds inches w.g..

M. C-Section Rooms and Nursery Suite:

1. Test Data: Include design and actual values for the following:

a. Airflow rate into and out of room cfm (L/s).
b. Differential Pressure Across doorway with door closed for more than one minute inches w.g..
c. Differential Pressure Across doorway with a single door open for ten seconds inches w.g..

N. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data: Include the following:

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: Include design and actual values for the following:

a. Airflow rate in cfm (L/s).
b. Entering-water temperature in deg F (deg C).
c. Leaving-water temperature in deg F (deg C).
d. Water pressure drop in feet of head or psig (kPa).
e. Entering-air temperature in deg F (deg C).
f. Leaving-air temperature in deg F (deg C).

O. 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: Include the following:

   a. Unit identification.
   b. Location.
   c. Unit make and model number.
   d. Manufacturer's compressor serial numbers.
   e. Compressor make.
   f. Compressor model and serial numbers.
   g. Refrigerant weight in lb (kg).
   h. Low ambient temperature cutoff in deg F (deg C).

2. Test Data: Include design and actual values for the following:

   a. Inlet-duct static pressure in inches wg (Pa).
   b. Outlet-duct static pressure in inches wg (Pa).
   c. Entering-air, dry-bulb temperature in deg F (deg C).
   d. Leaving-air, dry-bulb temperature in deg F (deg C).
   e. Condenser entering-water temperature in deg F (deg C).
   f. Condenser leaving-water temperature in deg F (deg C).
   g. Condenser water temperature differential in deg F (deg C).
   h. Condenser entering-water pressure in feet of head or psig (kPa).
   i. Condenser leaving-water pressure in feet of head or psig (kPa).
   j. Condenser water pressure differential in feet of head or psig (kPa).
   k. Control settings.
   l. Unloader set points.
   m. Low-pressure-cutout set point in psig (kPa).
   n. High-pressure-cutout set point in psig (kPa).
   o. Suction pressure in psig (kPa).
   p. Suction temperature in deg F (deg C).
   q. Condenser refrigerant pressure in psig (kPa).
   r. Condenser refrigerant temperature in deg F (deg C).
   s. Oil pressure in psig (kPa).
   t. Oil temperature in deg F (deg C).
   u. Voltage at each connection.
   v. Amperage for each phase.
   w. The kW input.
   x. Crankcase heater kW.
   y. Number of fans.
   z. Condenser fan rpm.
   aa. Condenser fan airflow rate in cfm (L/s).
   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.

3. Pump Test Data: Include design and actual values for the following:

   a. Make and model number.
   b. Manufacturer's serial number.
   c. Motor make and frame size.
   d. Motor horsepower and rpm.
   e. Voltage at each connection.
   f. Amperage for each phase.
   g. Water flow rate in gpm (L/s).

4. Water Test Data: Include design and actual values for the following:

   a. Entering-water temperature in deg F (deg C).
   b. Leaving-water temperature in deg F (deg C).
   c. Water temperature differential in deg F (deg C).
   d. Entering-water pressure in feet of head or psig (kPa).
   e. Leaving-water pressure in feet of head or psig (kPa).
   f. Water pressure differential in feet of head or psig (kPa).
   g. Water flow rate in gpm (L/s).

5. Air Data: Include design and actual values for the following:

   a. Average entering-air, wet-bulb temperature in deg F (deg C).
   b. Average leaving-air, wet-bulb temperature in deg F (deg C).
   c. Ambient wet-bulb temperature in deg F (deg C).

P. Heat-Exchanger/Converter Test Reports: For steam and hot-water heat exchangers, include the following:

1. Unit Data: Include the following:

   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and type.
   e. Model and serial numbers.
   f. Ratings.

2. Steam Test Data: Include design and actual values for the following:

   a. Inlet pressure in psig (kPa).
   b. Condensate flow rate in lb/h (kW).

3. Primary Water Test Data: Include design and actual values for the following:

   a. Entering-water temperature in deg F (deg C).
   b. Leaving-water temperature in deg F (deg C).
   c. Entering-water pressure in feet of head or psig (kPa).

d. Water pressure differential in feet of head or psig (kPa).
e. Water flow rate in gpm (L/s).

4. Secondary Water Test Data: Include design and actual values for the following:

a. Entering-water temperature in deg F (deg C).
b. Leaving-water temperature in deg F (deg C).
c. Entering-water pressure in feet of head or psig (kPa).
d. Water pressure differential in feet of head or psig (kPa).
e. Water flow rate in gpm (L/s).

Q. Pump Test Reports: For pumps, include the following data. Calculate impeller size by plotting the shutoff head on pump curves.

1. Unit Data: Include the following:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model and serial numbers.
f. Water flow rate in gpm (L/s).
g. Water pressure differential in feet of head or psig (kPa).
h. Required net positive suction head in feet of head or psig (kPa).
i. Pump rpm.
j. Impeller diameter in inches (mm).
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: Include design and actual values for the following:

a. Static head in feet of head or psig (kPa).
b. Pump shutoff pressure in feet of head or psig (kPa).
c. Actual impeller size in inches (mm).
d. Full-open flow rate in gpm (L/s).
e. Full-open pressure in feet of head or psig (kPa).
f. Final discharge pressure in feet of head or psig (kPa).
g. Final suction pressure in feet of head or psig (kPa).
h. Final total pressure in feet of head or psig (kPa).
i. Final water flow rate in gpm (L/s).
j. Voltage at each connection.
k. Amperage for each phase.

R. Venturi flow meter(s) Test Reports for Primary & Secondary Chilled Water Test Data: Include design and actual values for the following:

1. Unit Data: Include the following:

   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and type.
   e. Model and serial numbers.
   f. Ratings.

2. Test Data: Include the following:
   a. Entering-water pressure in feet of head or psig (kPa).
   b. Water pressure differential in feet of head or psig (kPa).
   c. Water flow rate in gpm (L/s).
   d. Date.
   e. Chiller Plant Operational Status.

S. Instrument Calibration Reports: For instrument calibration, include the following:

1. Report Data: Include the following:

   a. Instrument type and make.
   b. Serial number.
   c. Application.
   d. Dates of use.
   e. Dates of calibration.

3.20 ADDITIONAL TESTS

A. Within 90 days of completing testing, adjusting, and balancing, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial testing, adjusting, and balancing procedures were not performed during near-peak summer and winter conditions, perform additional inspections, testing, and adjusting during near-peak summer and winter conditions.

END OF SECTION 15990

SECTION 16010 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section includes basic general requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:

1. Codes and Standards.
2. Submittals.
3. Coordinated Power System Protection.
4. Coordination drawings.
5. Record documents.
6. Maintenance manuals.
7. Rough-ins.
8. Electrical installations.

1.2 RELATED WORK

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 16.

B. Related Sections: The following sections of Division 16 contain requirements that relate to this section:

1. Section 13100 LIGHTNING PROTECTION
2. Section 13810 CLOCK CONTROL
3. Section 13851 FIRE ALARM SYSTEMS
4. Section 16010 BASIC ELECTRICAL REQUIREMENTS
5. Section 16050 BASIC ELECTRICAL MATERIALS AND METHODS
6. Section 16055 OVERCURRENT PROTECTIVE DEVICE COORDINATION
7. Section 16060 GROUNDING AND BONDING
8. Section 16071 SEISMIC CONTROLS FOR ELECTRICAL WORK
9. Section 16075 ELECTRICAL IDENTIFICATION
10. Section 16080 ELECTRICAL TESTING
11. Section 16120 CONDUCTORS AND CABLES
12. Section 16121 CONTROL/SIGNAL TRANSMISSION MEDIA
13. Section 16124 MEDIUM-VOLTAGE CABLES
14. Section 16130 RACEWAYS AND BOXES

15. Section 16140 WIRING DEVICES
16. Section 16145 LIGHTING CONTROL DEVICES
17. Section 16271 MEDIUM VOLTAGE TRANSFORMERS
18. Section 16341 MEDIUM-VOLTAGE SWITCHGEAR
19. Section 16410 ENCLOSED SWITCHES AND CIRCUIT BREAKERS
20. Section 16415 TRANSFER SWITCHES
21. Section 16420 ENCLOSED CONTROLLERS
22. Section 16430 SWITCHGEAR
23. Section 16441 SWITCHBOARDS
24. Section 16442 PANELBOARDS
25. Section 16443 MOTOR CONTROL CENTERS
26. Section 16461 DRY-TYPE TRANSFORMERS (1000 V AND LESS)
27. Section 16491 FUSES
28. Section 16511 INTERIOR LIGHTING
29. Section 16521 EXTERIOR LIGHTING
30. Section 16570 DIMMING CONTROLS
31. Section 16630 ISOLATED POWER SYSTEMS
32. Section 16715 PREMISES TELEPHONE WIRING
33. Section 16725 NURSE CALL
34. Section 16725 PUBLIC ADDRESS SYSTEM

1.3 CODES AND STANDARDS

A. Electrical work shall comply with the current editions of the following codes:

1. BOCA - National Building Code

2. NFPA 70 - National Electrical Code

3. NFPA 72 - National Fire Alarm Code

4. NFPA 99 - Health Care Facilities

5. NFPA 101 - Life Safety Code

6. ANSI C2 - National Electrical Safety Code

B. Electrical work shall comply with the current standards of the following organizations:

1. U.S. Department of Health and Human Services - Guidelines for Construction and Equipment of Hospital and Medical Facilities

2. ADA - Americans with Disabilities Act

3. IEEE - Institute of Electrical and Electronics Engineers

4. IES - Illuminating Engineering Society

5. EIA/TIA - Electronic Industries Association/Telecommunications Industry Association

   a. EIA/TIA-568 Commercial Building Wiring Standard.
   b. EIA/TIA-569 Commercial Building Standard for Telecommunication Pathways and Spaces.

6. OSHA - Occupational Safety and Health Act

7. FM - Factory Mutual Association

8. UL - Underwriters' Laboratories

9. ANSI - American National Standards Institute

10. NEMA - National Electric Manufacturers Association

11. ASTM - American Society for Testing and Materials

C. In addition to complying with the specified requirements, comply with pertinent regulations of governmental agencies and authorities having jurisdiction including local and state building, plumbing, mechanical, electrical, fire, and health department codes and standards.

1.4 SUBMITTALS

A. General: Follow the procedures specified in Division 1.

B. Shop drawings shall be submitted in groups by systems. For example, all lighting fixtures, lamps, ballasts and accessories shall be submitted simultaneously in one package.

C. Refer to the applicable Division 16 section for specific submittal requirements. Where there are no specific submittal requirements in the specification section, provide manufacturer's standard literature showing the submittal items. Required shop drawings shall include but not be limited to:

1. AC cable and associated connectors (Hospital Grade)

2. Automatic transfer switches

3. Ballasts and accessories

4. Batteries and battery chargers

5. Boxes
6. Bridal ring cableways
7. Busways
8. Central control and monitoring systems
9. Circuit breakers
10. Clocks and elapsed timers
11. Dimmers
12. Dimming systems
13. Disconnect switches
14. Ductbanks and associated raceways
15. Fire alarm systems
16. Firestopping
17. Fuses
18. Grounding materials
19. Interior and exterior lighting fixtures
20. Isolated power systems
21. Lamps
22. Lighting control equipment
23. Lightning protection systems
24. Load interrupter switches
25. Low voltage wire and cable
26. Medium voltage cable, terminations and splices
27. MI cable and associated connectors and tools
28. Motor control centers

29. Motor starters

30. Nameplates and device markings

31. Nurse call systems

32. Panelboards and cabinets for Communication/Special Systems

33. Power factor correction capacitors

34. Public address systems

35. Raceway connectors and fittings

36. Raceways

37. Site lighting

38. Systems cabinets

39. Switchboards

40. Switchgear

41. Telephone system equipement

42. Transformers

43. Unit substations

44. Wireway and plug-in strip

45. Wiring devices

D. Increase, by the quantity listed below, the number of electrical related shop drawings, product data, and samples submitted, to allow for required distribution plus two copies of each submittal required, which will be retained by the Electrical Consulting Engineer.

1. Shop Drawings - Initial Submittal: 1 additional blue- or black-line prints.

2. Shop Drawings - Final Submittal: 1 additional blue- or black-line prints.

3. Product Data: 1 additional copy of each item.

4. Samples: 1 additional set.

E. Additional copies may be required by individual sections of these Specifications.

1.5 COORDINATION DRAWINGS

A. Prepare Coordination Drawings according to the requirements outlined in Division 1 to a 1/4-inch-equals-1-foot (1:50) scale or larger. Detail major elements, components, and systems of electrical equipment and materials in relation to each other and to other systems, installations, and building components. Indicate locations and space requirements for installation, access, and working clearance. Show where sequence and coordination of installations are important to the efficient flow of the Work. Coordinate drawing preparation with effort specified in other Specification Sections. Include the following:

1. Provisions for scheduling, sequencing, moving, and positioning large equipment in the building during construction.

2. Floor plans, elevations, and details, including the following:

   a. Clearances to meet safety requirements and for servicing and maintaining equipment, including space for equipment disassembly required for periodic maintenance.
   b. Equipment support details.
   c. Exterior wall, roof, and foundation penetrations of cable and raceway; and their relation to other penetrations and installations.
   d. Fire-rated interior wall and floor penetrations by electrical installations.
   e. Sizes and locations of required concrete pads and bases.

3. Reflected ceiling plans to coordinate and integrate installing air outlets and inlets, light fixtures, alarm and communication systems components, sprinklers, and other ceiling-mounted items.

1.6 RECORD DOCUMENTS

A. Prepare record documents in accordance with the requirements in Division 1. In addition to the requirements specified in Division 1, indicate installed conditions for:

1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.

2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.

3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

B. Engage the services of a Land Surveyor or Professional Engineer registered in the state in which the project is located as specified in Division 1 to record the locations and invert elevations of underground installations.

1.7 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1 Section "PROJECT CLOSEOUT." In addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing instructions and lubrication charts and schedules.

B. The minimum information that shall be furnished in the maintenance manual shall include the following:

1. Individual characteristics for trouble shooting sequences for each item of each:

a. Branch circuit panel.

b. Communication system.

c. Distribution panel.

d. Dry-type transformer.

e. Fire alarm system.

f. Individual motor starter.

g. Lighting control system.

h. Nurse call system.

i. Public Address system.

j. Switchboard.

2. Catalog cut sheets for every item for which a shop drawing is required.

3. Schedule of loads served from each:

a. Automatic transfer switch.

b. Branch circuit panel.

c. Distribution panel.

d. Lighting control system.

e. Switchboard.

4. On-hand spare parts list and complete parts list for each:

a. Communication system

b. Control system

c. Distribution panel.

d. Individual motor starter.

e. Switchboard.

5. Tap setting schedule for each:

a. Transformer.

b. Voltage regulator.

6. Overload element schedule for each motor starter.

7. Bolt tightening torques and inspection intervals on each:

a. Bolted bus connection.

b. Cable connection.

c. Miscellaneous bolted electrical connections.

8. Manufacturers' recommended cleaning intervals and special procedures for each:

   a. Cooling fins.

   b. Dry-type transformer coil assembly.

   c. Electrical equipment interior.

   d. Electrical equipment ventilation opening.

   e. Lighting fixture lenses and reflectors.

9. Main and arcing contact adjustment and replacement for each:

   a. Automatic transfer switch.

   b. Contactor.

   c. Circuit breaker.

   d. Fused switch.

   e. Motor starter.

10. Calibration and exercise procedures and intervals for each:

    a. Automatic transfer switch.

    b. Lighting control system.

    c. Molded case breaker.

11. "As designed" and "as left" adjustable circuit breaker settings.

12. Testing interval and target values for ground fault protection circuit relays.

13. Testing and trouble shooting procedures unique to special systems.

14. Approved special construction details that differ from the details shown on Drawings.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 2 through 16 for rough-in requirements.

3.2 ELECTRICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, and materials installation with other building components.

2. Verify all dimensions by field measurements.

3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.

4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

7. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.

9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

10. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

11. Install access panel or doors where units are concealed behind finished surfaces. Access panels and doors are specified in Division 16 Section "BASIC ELECTRICAL MATERIALS AND METHODS."

12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

END OF SECTION 16010

SECTION 16050 - BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Supporting devices for electrical components.
2. Concrete equipment bases.
3. Electrical demolition.
4. Cutting and patching for electrical construction.
5. Touchup painting.

1.3 RELATED WORK

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.4 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each type of product specified.

C. Shop Drawings detailing fabrication and installation of supports and anchorage for electrical items.

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.

1.6 COORDINATION

A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.

1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.

B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.

PART 2 - PRODUCTS

2.1 SUPPORTING DEVICES

A. Material: Cold-formed steel, with corrosion-resistant coating acceptable to authorities having jurisdiction.

B. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel or stainless steel.

C. Slotted-Steel Channel Supports: Comply with Division 5 Section "Metal Fabrications" for slotted channel framing.

1. Channel Thickness: Selected to suit structural loading.
2. Fittings and Accessories: Products of the same manufacturer as channel supports.

D. Raceway and Cable Supports: Manufactured clevis hangers, riser clamps, straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring-steel clamps.

E. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.

F. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Plugs have number and size of conductor gripping holes as required to suit individual risers. Body constructed of malleable-iron casting with hot-dip galvanized finish.

G. Expansion Anchors: Carbon-steel wedge or sleeve type.

H. Toggle Bolts: All-steel springhead type.

2.2 CONCRETE BASES

A. Concrete Forms and Reinforcement Materials: As specified in Division 3 Section "Cast-in-Place Concrete."

B. Concrete: 3000-psi (20.7-MPa), 28-day compressive strength as specified in Division 3 Section "Cast-in-Place Concrete."

2.3 TOUCHUP PAINT

A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.

B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

PART 3 - EXECUTION

3.1 ELECTRICAL EQUIPMENT INSTALLATION

A. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom.

B. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.

C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.

D. Right of Way: Give to raceways and piping systems installed at a required slope.

3.2 RACEWAY AND CABLE INSTALLATION

A. Conceal raceways and cables, unless otherwise indicated, within finished walls, ceilings, and floors.

B. Install raceways and cables at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Locate horizontal raceway runs above water and steam piping.

C. Use temporary raceway caps to prevent foreign matter from entering.

D. Make conduit bends and offsets so ID is not reduced. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.

E. Use raceway and cable fittings compatible with raceways and cables and suitable for use and location.

F. Install raceways embedded in slabs in middle third of slab thickness where practical, and leave at least 1-inch (25-mm) concrete cover.

1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
2. Space raceways laterally to prevent voids in concrete.
3. Install conduit larger than 1-inch trade size (DN27) parallel to or at right angles to main reinforcement. Where conduit is at right angles to reinforcement, place conduit close to slab support.
4. Nonmetallic conduit is not permitted for embedded branch circuits serving patient care areas. Metal raceway must be utilized to ensure redundant ground path.
5. Transition from nonmetallic tubing (where permitted) to rigid steel conduit before rising above floor.
6. Make bends in exposed parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for exposed parallel raceways.

G. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of the pull wire.

H. Install telephone and signal system raceways, 2-inch trade size (DN53) and smaller, in maximum lengths of 150 feet (45 m) and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements, in addition to requirements above.

I. Connect motors and equipment subject to vibration, noise transmission, or movement with a maximum of 72-inch (1830-mm) flexible conduit. Install LFMC in wet or damp locations. Install separate ground conductor across flexible connections.

3.3 ELECTRICAL SUPPORTING DEVICE APPLICATION

A. Damp Locations and Outdoors: Hot-dip galvanized materials, stainless steel materials, or nonmetallic, U-channel system components.

B. Dry Locations: Steel materials.

C. Selection of Supports: Comply with manufacturer's written instructions.

D. Strength of Supports: Adequate to carry present and future loads, times a safety factor of at least four; minimum of 200-lb (90-kg) design load.

3.4 SUPPORT INSTALLATION

A. Install support devices to securely and permanently fasten and support electrical components.

B. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assemblies and for securing hanger rods and conduits.

C. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.

D. Size supports for multiple raceway installations so capacity can be increased by a 25 percent minimum in the future.

E. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.

F. Install 1/4-inch- (6-mm-) diameter or larger threaded steel hanger rods, unless otherwise indicated.

G. Spring-steel fasteners specifically designed for supporting single conduits or tubing may be used instead of malleable-iron hangers for 1-1/2-inch (38-mm) and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings and for fastening raceways to slotted channel and angle supports.

H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.

I. Simultaneously install vertical conductor supports with conductors.

J. Separately support cast boxes that are threaded to raceways and used for fixture support. Support sheet-metal boxes directly from the building structure or by bar hangers. If bar hangers are used, attach bar to raceways on opposite sides of the box and support the raceway with an approved fastener not more than 24 inches (610 mm) from the box.

K. Install metal channel racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural elements of adequate strength.

L. Install sleeves for cable and raceway penetrations of concrete slabs and walls unless core-drilled holes are used. Install sleeves for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.

M. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Perform fastening according to the following unless other fastening methods are indicated:

1. Wood: Fasten with wood screws or screw-type nails.
2. Masonry: Toggle bolts on hollow masonry units and expansion bolts on solid masonry units.
3. New Concrete: Concrete inserts with machine screws and bolts.
4. Existing Concrete: Expansion bolts.
5. Steel: Welded threaded studs or spring-tension clamps on steel.

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

6. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or other items.
7. Light Steel: Sheet-metal screws.
8. Fasteners: Select so the load applied to each fastener does not exceed 25 percent of its proof-test load.

3.5 FIRESTOPPING

A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Firestop and Smoke Seals."

1. Fire stop sealing system shall be one of the following:

    a. Hilti One Plus or FS601
    b. Nelson Electric CLK
    c. IPC Corp. Flamesafe
    d. 3M

3.6 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger, in both directions, than supported unit. Follow supported equipment manufacturer's anchorage recommendations and setting templates for anchor-bolt and tie locations, unless otherwise indicated. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 3 Section "Cast-in-Place Concrete."

B. Refer to Division 16 Specification 16430, "Switchgear," for additional requirements for channel inserts in concrete pad.

3.7 DEMOLITION

A. Protect existing electrical equipment and installations indicated to remain. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.

B. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.

C. Abandoned Work: Cut and remove buried raceway and wiring, indicated to be abandoned in place, 2 inches (50 mm) below the surface of adjacent construction. Cap raceways and patch surface to match existing finish.

D. Remove demolished material from Project site.

E. Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.

3.8 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.

B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.9 FIELD QUALITY CONTROL

A. Inspect installed components for damage and faulty work, including the following:

1. Supporting devices for electrical components.
2. Concrete bases.
3. Electrical demolition.
4. Cutting and patching for electrical construction.
5. Access panels
6. Touchup painting.

3.10 REFINISHING AND TOUCHUP PAINTING

A. Refinish and touch up paint. Paint materials and application requirements are specified in Division 9 Section "Painting."

1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
4. Repair damage to paint finishes with matching touchup coating recommended by manufacturer.

3.11 CLEANING AND PROTECTION

A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.

B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

END OF SECTION 16050

SECTION 16055 - OVERCURRENT PROTECTIVE DEVICE COORDINATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes computer-based, fault-current and overcurrent protective device coordination studies, and the setting of these devices. The study must be performed by an independent agency experienced in the preparation of overcurrent protection device studies involving low voltage and medium voltage systems.

B. The study shall be performed and submitted with the shop drawing submittal for the electrical distribution equipment. Upon completion of the installation, the study shall be revised and resubmitted with actual field conditions.

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:

1. Coordination-study input data, including completed computer program input data sheets.
2. Coordination-study report.
3. Equipment evaluation report.
4. Setting 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 independent organization experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

C. Testing Agency Qualifications: Member company of the InterNational Electrical Testing Association.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association to supervise testing specified in Part 3.

D. Comply with IEEE 399 for general study procedures.

E. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Computer Software Developers: Subject to compliance with requirements, provide computer software programs developed by one of the following:

1. EDSA Micro Corporation.
2. 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, Table 7-4.

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.

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.

B. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices not submitted for approval with coordination study may not be used in study.

3.2 FAULT-CURRENT STUDY

A. Source Impedance: Utility company's fault-current contribution and as an infinite bus on utility system at the overhead pole terminations.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project and use approved computer software program to calculate values. 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 the following:

1. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.50.
2. Low-Voltage Fuses: IEEE C37.46.
3. Circuit Breakers: IEEE C37.13.

E. Study Report: Enter calculated X/R ratios and interrupting (5-cycle) fault currents on electrical distribution system diagram of the report. List other output values from computer analysis, including momentary (1/2-cycle), interrupting (5-cycle), and 30-cycle fault-current values for 3-phase, 2-phase, and phase-to-ground faults.

F. Equipment Evaluation Report: Prepare a report on the adequacy of overcurrent protective devices and conductors by comparing fault-current ratings of these devices with calculated fault-current momentary and interrupting duties.

3.3 COORDINATION STUDY

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 16 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 showing the following:

a. Load current that is the basis for sizing continuous ratings of circuits for cables and equipment.
b. Circuit-breaker and fuse-current ratings and types.
c. Relays and associated power and current transformer ratings and ratios.
d. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
e. Generator kilovolt amperes, size, voltage, and source impedance.
f. Cables. Indicate conduit material, sizes of conductors, conductor insulation, and length.
g. Busway ampacity and impedance.
h. 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:

a. Special load considerations, including starting inrush currents and frequent starting and stopping.
b. Magnetic inrush current overload capabilities of transformers.
c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
d. Ratings, types, and settings of utility company's overcurrent protective devices.
e. Special overcurrent protective device settings or types stipulated by utility company.
f. Time-current-characteristic curves of devices indicated to be coordinated.
g. 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.
h. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
i. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

B. Obtain Met-Ed's acceptance of relay settings.

C. Perform coordination study and prepare a written report using the results of fault-current study and approved computer software program. Comply with IEEE 399.

D. Comply with NFPA 70 for overcurrent protection of circuit elements and devices.

E. Comply with IEEE 141 and IEEE 242 recommendations for fault currents and time intervals.

F. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

a. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
b. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device shall protect transformer according to IEEE C57.12.00, for fault currents.

G. 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. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.

H. 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 series devices, including power utility company's upstream devices. Show the following specific 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.

3. Completed data sheets for setting of overcurrent protective devices.

3.4 OVERCURRENT PROTECTIVE DEVICE SETTING

A. Testing: Engage a qualified testing agency to perform the following device setting and to prepare test reports.

1. After installing overcurrent protective devices and during energizing process of electrical distribution system, perform the following:

   a. Verify that overcurrent protective devices meet parameters used in studies.
   b. Adjust devices to values listed in study results.

END OF SECTION 16055

SECTION 16060 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.3 SUBMITTALS

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

B. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

C. Field Test Reports: Submit written test reports to include 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.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or 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 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; for overhead-line construction and medium-voltage underground construction, comply with IEEE C2.

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:

1. Grounding Conductors, Cables, Connectors, and Rods:

a. Apache Grounding/Erico Inc.
b. Chance/Hubbell.
c. Copperweld Corp.
d. Erico Inc.; Electrical Products Group.
e. Framatome Connectors/Burndy Electrical.
f. Hastings Fiber Glass Products, Inc.
g. Ideal Industries, Inc.
h. ILSCO.
i. Kearney/Cooper Power Systems.
j. O-Z/Gedney Co.; a business of the EGS Electrical Group.
k. Raco, Inc.; Division of Hubbell.
l. Thomas & Betts, Electrical.

2.2 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Division 16 Section "Conductors and Cables."

B. Material: Copper.

C. Equipment Grounding Conductors: Insulated with green-colored insulation.

D. Isolated Ground Conductors: Insulated with green-colored insulation with yellow stripe. On feeders with isolated ground, use colored tape, alternating bands of green and yellow tape to provide a minimum of three bands of green and two bands of yellow.

E. Grounding Electrode Conductors: Stranded cable.

F. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.

G. Bare Copper Conductors: Comply with the following:

1. Solid Conductors: ASTM B 3.

2. Assembly of Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.

H. Copper Bonding Conductors: As follows:

1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4 inch (6.4 mm) in diameter.
2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches (42 mm) wide and 1/16 inch (1.5 mm) thick.
4. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches (42 mm) wide and 1/16 inch (1.5 mm) thick.

I. Grounding Bus: Bare, annealed copper bars of rectangular cross section, with insulators.

2.3 CONNECTOR PRODUCTS

A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Bolted Connectors: Bolted-pressure-type connectors, or compression type.

C. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.

2.4 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel.

1. Size: 5/8" diameter by 96 inches in length (16 by 2400 mm).

B. Test Wells: Provide handholes.

PART 3 - EXECUTION

3.1 APPLICATION

A. In raceways, use insulated equipment grounding conductors.

B. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells.

C. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.

D. Ground Rod Clamps at Test Wells: Use bolted pressure clamps with at least two bolts.

E. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Use insulated spacer; space 1 inch (25.4 mm) from wall and support from wall 6 inches (150 mm) above finished floor, unless otherwise indicated.

2. Coordinate ground bus installation with equipment installation.

3. If no size is indicated on drawings, provide 2' by 2",1/4"thick copper bus for ground bus.

F. Underground Grounding Conductors: Use tinned-copper conductor, No. 4/0 AWG minimum. Bury at least 24 inches (600 mm) below grade or bury 12 inches (300 mm) above duct bank when installed as part of the duct bank.

3.2 EQUIPMENT GROUNDING CONDUCTORS

A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

B. Install equipment grounding conductors in all feeders and circuits.

C. Install insulated equipment grounding conductor with all circuit conductors:

D. X-Ray Equipment Circuits: Install insulated equipment grounding conductor as indicated in circuits supplying x-ray equipment.

E. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.

F. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners and heaters. Bond conductor to each unit and to air duct.

G. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate equipment grounding conductor to each electric water heater, heat-tracing, and antifrost heating cable. Bond conductor to heater units, piping, connected equipment, and components.

H. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, 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-24-inch (6.4-by-50-by-600-mm) grounding bus.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.3 COUNTERPOISE

A. Ground the steel framework of the building with a driven ground rod at the base of every corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart. Provide a grounding conductor (counterpoise), electrically connected to each ground rod and to each steel column, extending around the perimeter of the building. Use tinned-copper conductor not less than No. 4/0 AWG for counterpoise and for tap to building steel. Bury counterpoise not less than 24 inches (450 mm) below grade and 24 inches (600 mm) from building foundation.

3.4 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

C. Metal Water Service Pipe: Provide 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 by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

D. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.

E. Install one test well for each service at the ground rod electrically closest to the service entrance. Set top of well flush with finished grade or floor.

F. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.

G. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.

3.5 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

D. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

E. Connections at Test Wells: Use compression-type connectors on conductors and make bolted- and clamped-type connections between conductors and ground rods.

F. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values.

G. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.6 FIELD QUALITY CONTROL

A. Testing: Engage a qualified testing agency to perform the following field quality-control testing:

B. Testing: Perform the following field quality-control testing:

1. After installing grounding system but before permanent electrical circuitry has 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, and at ground test wells. Measure ground resistance not less than two full days after the last trace of precipitation, and without the 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. Perform tests, by the fall-of-potential method according to IEEE 81.
3. Provide drawings locating each 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.

    a. Equipment Rated 500 kVA and Less: 10 ohms.
    b. Equipment Rated 500 to 1000 kVA: 5 ohms.
    c. Equipment Rated More Than 1000 kVA: 3 ohms.
    d. Substations and Pad-Mounted Switching Equipment: 5 ohms.
    e. Manhole Grounds: 10 ohms.

4. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

3.7 GRADING AND PLANTING

A. Restore surface features, including vegetation, at areas disturbed by Work of this Section. Reestablish original grades, unless otherwise indicated. If sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition. Include application of topsoil, fertilizer, lime, seed, sod, sprig, and mulch. Comply with Division 2 Section "Landscaping." Maintain restored surfaces. Restore disturbed paving as indicated.

END OF SECTION 16060

SECTION 16071 - SEISMIC CONTROLS FOR ELECTRICAL WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes seismic restraints and other earthquake-damage-reduction measures for electrical components. It complements optional seismic construction requirements in the various electrical component Sections.

1.3 DEFINITIONS

A. BOCA: BOCA National Building Code.

B. SBC: Standard Building Code.

C. UBC: Uniform Building Code.

D. Seismic Restraint: A fixed device (a seismic brace, an anchor bolt or stud, or a fastening assembly) used to prevent vertical or horizontal movement, or both vertical and horizontal movement, of an electrical system component during an earthquake.

E. Mobile Structural Element: A part of the building structure such as a slab, floor structure, roof structure, or wall that may move independent of other mobile structural elements during an earthquake.

1.4 SUBMITTALS

A. Product Data: Illustrate and indicate types, styles, materials, strength, fastening provisions, and finish for each type and size of seismic restraint component used.

1. Anchor Bolts and Studs: Tabulate types and sizes, complete with report numbers and rated strength in tension and shear as evaluated by **[ICBO Evaluation Service] [an agency approved by authorities having jurisdiction]**.

B. Shop Drawings: For anchorage and bracing not defined by details and charts on Drawings. Indicate materials, and show designs and calculations signed and sealed by a professional engineer.

1. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
2. Details: Detail fabrication and arrangement. Detail attachment of restraints to both structural and restrained items. Show attachment locations, methods, and spacings, identifying components and listing their strengths. Indicate direction and value of forces transmitted to the structure during seismic events.
3. Preapproval and Evaluation Documentation: By **[California Office of Statewide Health Planning and Development (OSHPD)] [ICBO Evaluation Service] [an agency approved by authorities having jurisdiction]**, showing maximum ratings of restraints and the basis for approval (tests or calculations).

C. Coordination Drawings: Plans and sections drawn to scale and coordinating seismic bracing for electrical components with other systems and equipment, including other seismic restraints, in the vicinity.

D. Product Certificates: Signed by manufacturers of seismic restraints certifying that products furnished comply with requirements.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

F. Material Test Reports: From a qualified testing agency indicating and interpreting test results of seismic control devices for compliance with requirements indicated.

1.5 QUALITY ASSURANCE

A. Comply with seismic restraint requirements in **[BOCA] [California Building Code/Code of Regulations of OSHPD]** [SBC] [UBC], unless requirements in this Section are more stringent.

B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing seismic engineering services, including the design of seismic restraints, that are similar to those indicated for this Project.

C. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated.

1.6 PROJECT CONDITIONS

A. Project Seismic Zone and Zone Factor as Defined in UBC: [**Zone 1, Zone Factor 0.075**] [**Zone 2A, Zone Factor 0.15**] [**Zone 2B, Zone Factor 0.20**] [**Zone 3, Zone Factor 0.30**] [**Zone 4, Zone Factor 0.40**].

B. Occupancy Category as Defined in UBC: [I] [II] [III] [IV].

C. Acceleration Factor: [0.2G] [0.4G] [0.5G] [0.75G] [1.0G].

1.7 PROJECT CONDITIONS

A. Acceleration Factor: **<Insert value.>**

B. Project Seismic Hazard Exposure Group as Defined in BOCA or SBC: [I] [II] [III].

1.8 COORDINATION

A. Coordinate layout and installation of seismic bracing with building structural system and architectural features, and with mechanical, fire-protection, electrical, and other building features in the vicinity.

B. Coordinate concrete bases with building structural system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Amber/Booth Company, Inc.
2. B-Line Systems, Inc.
3. Erico, Inc.
4. GS Metals Corp.
5. Loos & Company, Inc.
6. Mason Industries, Inc,
7. Powerstrut.
8. Thomas & Betts Corp.
9. Unistrut Corporation.

2.2 MATERIALS

A. Use the following materials for restraints:

1. Indoor Dry Locations: Steel, zinc plated.
2. Outdoors and Damp Locations: Galvanized steel.
3. Corrosive Locations: Stainless steel.

2.3 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

A. Strength: Defined in reports by ICBO Evaluation Service or another agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

B. Concrete and Masonry Anchor Bolts and Studs: Steel-expansion wedge type.

C. Concrete Inserts: Steel-channel type.

D. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.

E. Welding Lugs: Comply with MSS SP-69, Type 57.

F. Beam Clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.

G. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

2.4 SEISMIC BRACING COMPONENTS

A. Slotted Steel Channel: 1-5/8-by-1-5/8-inch (41-by-41-mm) cross section, formed from 0.1046-inch- (2.7-mm-) thick steel, with 9/16-by-7/8-inch (14-by-22-mm) slots at a maximum of 2 inches (50 mm) o.c. in webs, and flange edges turned toward web.

1. Materials for Channel: ASTM A 570, GR 33.
2. Materials for Fittings and Accessories: ASTM A 575, ASTM A 576, or ASTM A 36.
3. Fittings and Accessories: Products of the same manufacturer as channels and designed for use with that product.
4. Finish: Baked, rust-inhibiting, acrylic-enamel paint applied after cleaning and phosphate treatment, unless otherwise indicated.

B. Channel-Type Bracing Assemblies: Slotted steel channel, with adjustable hinged steel brackets and bolts.

C. Cable-Type Bracing Assemblies: Zinc-coated, high-strength steel wire rope cable attached to steel thimbles, brackets, and bolts designed for cable service.

1. Arrange units for attachment to the braced component at one end and to the structure at the other end.
2. Wire Rope Cable: Comply with ASTM 603. Use 49- or 133-strand cable with a minimum strength of 2 times the calculated maximum seismic force to be resisted.

D. Hanger Rod Stiffeners: Slotted steel channels with internally bolted connections to hanger rod.

PART 3 - EXECUTION

3.1 APPLICATION

A. Generator Sets: Comply with Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."

3.2 INSTALLATION

A. Install seismic restraints according to applicable codes and regulations and as approved by authorities having jurisdiction, unless more stringent requirements are indicated.

3.3 STRUCTURAL ATTACHMENTS

A. Use bolted connections with steel brackets, slotted channel, and slotted-channel fittings to spread structural loads and reduce stresses.

B. Attachments to New Concrete: Bolt to channel-type concrete inserts or use expansion anchors.

C. Attachments to Existing Concrete: Use expansion anchors.

D. Holes for Expansion Anchors in Concrete: Drill at locations and to depths that avoid reinforcing bars.

E. Attachments to Solid Concrete Masonry Unit Walls: Use expansion anchors.

F. Attachments to Hollow Walls: Bolt to slotted steel channels fastened to wall with expansion anchors.

G. Attachments to Wood Structural Members: Install bolts through members.

H. Attachments to Steel: Bolt to clamps on flanges of beams or on upper truss chords of bar joists.

3.4 ELECTRICAL EQUIPMENT ANCHORAGE

A. Anchor rigidly to a single mobile structural element or to a concrete base that is structurally tied to a single mobile structural element.

B. Anchor panelboards, motor-control centers, motor controls, switchboards, switchgear, transformers, unit substations, fused power-circuit devices, transfer switches, busways, battery racks, static uninterruptible power units, power conditioners, capacitor units, communication system components, and electronic signal processing, control, and distribution units as follows:

1. Size concrete bases so expansion anchors will be a minimum of 10 bolt diameters from the edge of the concrete base.
2. Concrete Bases for Floor-Mounted Equipment: Use female expansion anchors and install studs and nuts after equipment is positioned.
3. Bushings for Floor-Mounted Equipment Anchors: Install to allow for resilient media between anchor bolt or stud and mounting hole in concrete.
4. Anchor Bolt Bushing Assemblies for Wall-Mounted Equipment: Install to allow for resilient media where equipment or equipment-mounting channels are attached to wall.
5. Torque bolts and nuts on studs to values recommended by equipment manufacturer.

3.5 SEISMIC BRACING INSTALLATION

A. Install bracing according to spacings and strengths indicated by approved analysis.

B. Expansion and Contraction: Install to allow for thermal movement of braced components.

C. Cable Braces: Install with maximum cable slack recommended by manufacturer.

D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to the structure at flanges of beams, upper truss chords of bar joists, or at concrete members.

3.6 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Make flexible connections in raceways, cables, wireways, cable trays, and busways where they cross expansion and seismic control joints, where adjacent sections or branches are

supported by different structural elements, and where they terminate at electrical equipment anchored to a different mobile structural element from the one supporting them.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform the following field quality-control testing:

B. Testing Agency: Engage a qualified testing agency to perform the following field quality-control testing:

C. Testing: Test pull-out resistance of seismic anchorage devices.

1. Provide necessary test equipment required for reliable testing.
2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
3. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.
4. Obtain Architect's approval before transmitting test loads to the structure. Provide temporary load-spreading members.
5. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
6. Test to 90 percent of rated proof load of device.
7. If a device fails the test, modify all installations of same type and retest until satisfactory results are achieved.
8. Record test results.

END OF SECTION 16071

SECTION 16075 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes electrical identification materials and devices required to comply with ANSI C2, NFPA 70, OSHA standards, and authorities having jurisdiction.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Schedule of Nomenclature: An index of electrical equipment and system components used in identification signs and labels.

C. Samples: For each type of label and sign to illustrate color, lettering style, and graphic features of identification products.

1.4 QUALITY ASSURANCE

A. Comply with ANSI C2.

B. Comply with NFPA 70.

C. Comply with ANSI A13.1 and NFPA 70 for color-coding.

D. Comply with NFPA 99.

PART 2 - PRODUCTS

2.1 RACEWAY AND CABLE LABELS

A. Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

1. Color: Black letters on orange field.
2. Legend: Indicates voltage and service.

B. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl with legend overlaminated with a clear, weather- and chemical-resistant coating.

C. Pretensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the line it identifies and arranged to stay in place by pretensioned gripping action when placed in position.

D. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide (0.08 mm thick by 25 to 51 mm wide).

E. Underground-Line Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape.

1. Not less than 6 inches wide by 4 mils thick (152 mm wide by 0.102 mm thick).
2. Compounded for permanent direct-burial service.
3. Embedded continuous metallic strip or core.
4. Printed legend indicating type of underground line.

F. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

G. Aluminum, Wraparound Marker Bands: Bands cut from 0.014-inch- (0.4-mm-) thick aluminum sheet, with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.

H. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.

I. Aluminum-Faced, Card-Stock Tags: Weather-resistant, 18-point minimum card stock faced on both sides with embossable aluminum sheet, 0.002 inch (0.05 mm) thick, laminated with moisture-resistant acrylic adhesive, punched for fasteners, and preprinted with legends to suit each application.

J. Brass or Aluminum Tags: 2 by 2 by 0.05-inch (51 by 51 by 1.3-mm) metal tags with stamped legend, punched for fastener.

2.2 NAMEPLATES AND SIGNS

A. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

B. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.

1. Normal power: Engraved legend with white lettering on black face.
2. Emergency Power: Engraved legend with white lettering on red face.
3. Punched or drilled for mechanical fasteners.

C. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 1/4-inch (6.4-mm) grommets in corners for mounting.

D. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for the application. 1/4-inch (6.4-mm) grommets in corners for mounting.

E. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

2.3 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength: 50 lb (22.3 kg) minimum.
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: According to color-coding.

B. Paint: Formulated for the type of surface and intended use.

1. Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.
2. Primer for Concrete Masonry Units: Heavy-duty-resin block filler.
3. Primer for Concrete: Clear, alkali-resistant, binder-type sealer.
4. Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those

required by codes and standards. Use consistent designations throughout Project. Refer to section 2.2.B.1 above for normal and emergency power color designations.

C. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before applying.

E. Circuits with More Than 600 V: Identify raceway and cable with "DANGER--HIGH VOLTAGE" in black letters 2 inches (51 mm) high, stenciled with paint at 10-foot (3-m) intervals over a continuous, painted orange background. Identify the following:

1. Entire floor area directly above conduits running beneath and within 12 inches (305 mm) of a basement or ground floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to conduits concealed within wall.
3. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in the building, or concealed above suspended ceilings.
4. Entire surface of exposed conduits.

F. Install painted identification according to manufacturer's written instructions and as follows:

1. Clean surfaces of dust, loose material, and oily films before painting.
2. Prime surfaces using type of primer specified for surface.
3. Apply one intermediate and one finish coat of enamel.

G. Color Banding Raceways and Exposed Cables: Band exposed and accessible raceways of the systems listed below:

1. Bands: Pretensioned, wraparound plastic sleeves; colored adhesive tape; or a combination of both. Make each color band 2 inches (51 mm) wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.
2. Band Locations: At changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
3. Apply the following colors to the systems listed below:

   a. Emergency: Red.
   b. Fire Alarm: Orange.
   c. Nurse call: Green.
   d. Sound/Intercom/Paging: Blue.
   e. Telephone: Yellow.
   f. Security: Brown.

H. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.

I. Circuit Identification Labels on Boxes: Install labels externally.

1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
2. Concealed Boxes: Plasticized card-stock tags.
3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.

J. Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Where width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches (400 mm) overall, use a single line marker. Install line marker for underground wiring, both direct-buried cables and cables in raceway.

K. Color-Coding of Secondary Phase Conductors: Use the following colors for service feeder and branch-circuit phase conductors:

1. 208/120-V Conductors:

a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.
d. Neutral: Natural Grey or White.
e. Ground: Green.

2. 480/277-V Conductors:

a. Phase A: Brown.
b. Phase B: Orange.
c. Phase C: Yellow.
d. Neutral: Natural Grey or White.
e. Ground: Green.

3. Factory apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire for sizes larger than No. 10 AWG:

a. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches (150 mm) 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. Use 1-inch- (25-mm-) wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.

b. Colored cable ties applied in groups of three ties of specified color to each wire at each terminal or splice point starting 3 inches (76 mm) from the terminal and spaced 3 inches (76 mm) apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length.

L. Device Cover Plate Identification: Annotate with 1/8 inch high black capital letters designating as follows:

1. All receptacle coverplates shall be labeled with the following branch circuit source information:

a. Panelboard number.

b. Circuit number.

c. Example: "N21N1 - 5"

2. Receptacles protected upstream on associated branch circuit by a ground fault circuit interrupter device shall be labeled "GFCI PROTECTED".

M. Power-Circuit Identification: Metal tags or aluminum, wraparound marker bands for cables, feeders, and power circuits in pull and junction boxes, manholes, electrical rooms.

1. Legend: 1/4-inch- (6.4-mm-) steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.
2. Tag Fasteners: Nylon cable ties.
3. Band Fasteners: Integral ears.

N. Apply identification to conductors as follows:

1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.
2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.

O. Apply warning, caution, and instruction signs as follows:

1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.

2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch- (9-mm-) high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

P. Equipment Identification Labels: Engraved phenolic. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high lettering on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high. Follow color coding of nameplates for normal and emergency power as indicated in 2.2.B.1 above:

1. Panelboards, electrical cabinets, and enclosures.
2. Access doors and panels for concealed electrical items.
3. Electrical switchgear.
4. Emergency system boxes and enclosures.
5. Disconnect switches.
6. Enclosed circuit breakers.
7. Motor starters.
8. Push-button stations.
9. Power transfer equipment.
10. Contactors.
11. Remote-controlled switches.
12. Control devices.
13. Transformers.
14. TVSS equipment.
15. Fire alarm master station or control panel.
16. Low voltage system (master clock, nurse call, etc.) head-end stations.
17. Electric heat tracing.

Q. Electrical distribution equipment shall be labeled with equipment name and source of power unless otherwise indicated in the specifications.

END OF SECTION 16075

SECTION 16080 - ELECTRICAL TESTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes general requirements for electrical field testing and inspecting. Detailed requirements are specified in each Section containing components that require testing. General requirements include the following:

1. Qualifications of testing agencies and their personnel.
2. Suitability of test equipment.
3. Calibration of test instruments.
4. Coordination requirements for testing and inspecting.
5. Reporting requirements for testing and inspecting.

B. Allowances: Electrical tests and inspections specified in various Division 13 and 16 Sections are covered by a testing and inspecting allowance specified in Division 1 Section "Allowances." See Division 1 Section "Allowances" for what is included in allowance amount, the amount of the allowance, payment procedures for allowances, changes to allowance amounts, and disposition of unused portions of allowance.

1.3 QUALITY ASSURANCE

A. Testing Agency Qualifications: As specified in each Section containing electrical testing requirements and in subparagraph and associated subparagraph below.

1. Independent Testing Agencies: Independent of manufacturers, suppliers, and installers of components to be tested or inspected.

a. Testing Agency's Field Supervisor for Power Component Testing: 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 Division 16 power component Sections.

B. Test Equipment Suitability: Comply with NETA ATS, Section 5.2.

C. Test Equipment Calibration: Comply with NETA ATS, Section 5.3.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 GENERAL TESTS AND INSPECTIONS

A. If a group of tests are specified to be performed by an independent testing agency, prepare systems, equipment, and components for tests and inspections, and perform preliminary tests to ensure that systems, equipment, and components are ready for independent agency testing. Include the following minimum preparations as appropriate:

1. Perform insulation-resistance tests.
2. Perform continuity tests.
3. Perform rotation test (for motors to be tested).
4. Provide a stable source of single-phase, 208/120-V electrical power for test instrumentation at each test location.

B. Test and Inspection Reports: In addition to requirements specified elsewhere, report the following:

1. Manufacturer's written testing and inspecting instructions.
2. Calibration and adjustment settings of adjustable and interchangeable devices involved in tests.
3. Tabulation of expected measurement results made before measurements.
4. Tabulation of "as-found" and "as-left" measurement and observation results.

END OF SECTION 16080

SECTION 16120 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less.

B. Related Sections include the following:

1. Division 16 Section "Control/Signal Transmission Media" for transmission media used for control and signal circuits.
2. Division 16 Section "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.

1.3 SUBMITTALS

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

B. Qualification Data: For testing agency.

C. Field Quality-Control Test Reports: From a qualified testing and inspecting agency engaged by Contractor.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or 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 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.

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 CONDUCTORS AND CABLES

A. Manufacturers:

1. Alcan Aluminum Corporation; Alcan Cable Div.
2. American Insulated Wire Corp.; a Leviton Company.
3. General Cable Corporation.
4. Senator Wire & Cable Company.
5. Southwire Company.

B. Refer to Part 3 "Conductor and Insulation Applications" Article for insulation type, cable construction, and ratings.

C. Conductor Material: Copper complying with NEMA WC 5; solid conductor for No. 10 AWG and smaller, stranded for No. 8 AWG and larger.

D. Conductor Insulation Types: Type THHN-THWN complying with NEMA WC 5.

E. Multiconductor Cable: Hospital Grade Armored cable, Type AC with ground wire.

2.3 CONNECTORS AND SPLICES

A. Manufacturers:

1. AFC Cable Systems, Inc.
2. AMP Incorporated/Tyco International.
3. Hubbell/Anderson.

4. O-Z/Gedney; EGS Electrical Group LLC.
5. 3M Company; Electrical Products Division.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - EXECUTION

3.1 CONDUCTOR AND INSULATION APPLICATIONS

A. Service Entrance: Type USE.

B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and in Crawlspaces: 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 and below Slabs-on-Grade: Type THHN-THWN, single conductors in raceway.

H. Underground Feeders and Branch Circuits: Type UF multiconductor cable.

I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord.

J. Fire Alarm Circuits: Power-limited, fire-protective, signaling circuit cable, in accordance with manufacturer's recommendations.

K. Class 1 Control Circuits: Type THHN-THWN, in raceway.

L. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.2 INSTALLATION

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 16 Section "Basic Electrical Materials and Methods."

F. Seal around cables penetrating fire-rated elements according to Division 7 Section "Through-Penetration Firestop Systems."

G. Identify and color-code conductors and cables according to Division 16 Section "Electrical Identification."

3.3 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 **12 inches (300 mm)** of slack.

3.4 FIELD QUALITY CONTROL

A. Testing: Engage a qualified testing agency to perform the following field quality-control testing:

B. Testing: Perform the following field quality-control testing:

1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements.
2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.3.1. Certify compliance with test parameters.

C. 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.

END OF SECTION 16120

SECTION 16121 - CONTROL/SIGNAL TRANSMISSION MEDIA

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following types of control and signal transmission media:

1. Coaxial cable.
2. Twisted-pair cable.
3. Optical fiber cable.
4. Optical fiber connectors and couplers.

B. Related Sections include the following:

1. Division 16 Section "Basic Electrical Materials and Methods" for building wire used for control or signal circuits.
2. Division 16 Section "Wires and Cables" for building wire used for control or signal circuits.

1.3 DEFINITIONS

A. PTFE: Polytetrafluoroethylene.

1.4 SUBMITTALS

A. Product Data: For control/signal transmission media.

B. Product Certificates: Signed by manufacturers of transmission media certifying that the products furnished comply with requirements and that they have been coordinated with and accepted by the manufacturer of connected equipment.

C. Samples of each of the following cable types for approval:

1. Optical fiber riser cables.
2. Composite copper and optical fiber cables.

D. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

F. Maintenance Data: For transmission media to include in the maintenance manuals specified in Division 1.

G. The submittal shall contain reference to specified manufacturers' catalog numbers which shall be qualified in writing if required to meet the product performance or characteristics described in the Project's drawings or specifications.

H. All submittals shall contain a list of all equipment and materials to be supplied by the contractor for completion of the Project. Only materials and equipment referenced in the specifications shall be accepted. In the event that a new number since the preparation of the Project's drawings and specifications has superceded any specified manufacturer's part number, the new number shall be provided with the old catalog number noted as a reference on the submittal.

I. All equipment and material submittals shall have a letter included with the submittal that lists the delivery lead-time requirements for each item in the submittal. The delivery lead-time is the number of CALENDAR days between the time the order for an item is placed with the distributor and the time it can be delivered to the work site. No proposed item shall be reviewed without its delivery lead time indicated.

J. The contractor shall provide a complete set of as-built drawings to MMC on completion of this project and prior to acceptance. As-builts shall indicate all types and sizes of facility pathways, junctions, termination points. All as-builts shall be in hard copy and digital formats, which shall include (2) B sized and (2) D sized prints. Additionally, upon substantial completion of the project an accurate copy of the field documentation for all cabling shall be submitted immediately to the Cable Management Technician for review and Final project As-builts shall be furnished to MMC Telecommunications per project completion schedule.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: In addition to requirements specified in Division 1 Section "Quality Control," an independent testing agency shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907; or shall be a full-member company of the InterNational Electrical Testing Association.

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 all cable of each type through one source from a single manufacturer.

C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.
2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

D. All cabling shall be provided, installed, supported and fastened according to NFPA, state, local and the ANSI/EIA/TIA 568A Commercial Building Telecommunications Cabling Standards and the ANSI/EIA/TIA 569 specification.

E. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect at least 2 days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.
3. Coordinate all outages and service interruptions with the architect and the owner.

1.7 COORDINATION

A. Coordinate with and obtain review of cable characteristics and certification for use with the connected system equipment by the connected equipment manufacturers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, in accordance with the requirements stipulated within this specification, including Appendix A:

1. Electronic Cables:

a. Berk-Tek, Inc.
b. Essex
c. General

d. Superior
e. Mohawk Wire and Cable Corp.
f. Ortronics.

2. Optical Fiber Cables, Connectors & Equipement:

a. Siecor Corp.

2.2 ELECTRONIC CABLE

A. Single-Conductor Plenum Coaxial: 75-ohm characteristic impedance; solid bare copper central conductor; foamed PTFE dielectric, 100 percent coverage tinned-copper, double-braid shield; PTFE jacket; suitable for installation in air-handling spaces; complying with MIL-C-17, Type RG-11/U for riser applications and Type RG-6 for Station locations.

B. Twisted-Pair Plenum: 4-Pairs, Category 5-E UTP; No. 24 AWG, 7-strand, tinned-copper conductors; PTFE insulation; overall aluminum/polyester shield; No. 22 AWG tinned-copper drain wire; PTFE jacket; suitable for use in air-handling spaces.

2.3 OPTICAL FIBER CABLES AND CONNECTORS

A. Cables: Factory-fabricated, single-channel, low-loss, glass-type, optical fiber, multimode, graded-index cables. Provide 24 strand Siecor MIC cable with PVC jacket.

B. Construction: Single fiber with a 50-micron core diameter and a 125-micron cladding diameter; 250-micron outside-jacket diameter. Provide innerduct for all riser applications.

C. Ratings: 4.0-dB/850-nm maximum attenuation, 400-MHz/km minimum bandwidth, 0.2 nominal numerical aperture.

D. Physical Characteristics: 7.5-kg/km, 500-N maximum installation load, 150-N maximum operational load, 30-mm minimum bending radius.

E. Operating Temperature Range: Minus 20 to 70 deg C.

F. Optical Fiber Connectors: Stainless-steel optical fiber cable connectors, capable of terminating optical fiber glass cables, with diameters ranging from 125 to 1000 microns. Fabricate connectors with optical fiber, self-centering, axial alignment mechanisms. Select resilient tip SMA-type connectors with quick-connect features and with insertion loss of not greater than 1.0 dB. NOTE: See Appendix A for approved connector listing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine raceways and other elements to receive cables for compliance with requirements for installation tolerances and other conditions affecting performance of transmission media. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install cable as indicated, according to manufacturer's written instructions.

B. Outlets shall be mounted in standard 2 ½"x2"x4" backboxes.

C. Install transmission media without damaging conductors, shield, or jacket.

1. Do not bend cable, in handling or installation, to smaller radii than minimum recommended by manufacturer.

D. Pull cables without exceeding cable manufacturer's recommended pulling tensions.

1. Pull cables simultaneously if more than one is being installed in same raceway.
2. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation.
3. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage media or raceway.

E. Install exposed cables parallel and perpendicular to surfaces or exposed structural members, and follow surface contours where possible.

F. Support cables according to Division 16 Section "Basic Electrical Materials and Methods."

G. Use splice and tap connectors compatible with cable material.

1. Make no splices except at indicated splice points.

H. Seal around cables penetrating fire-rated elements according to Division 7 Section "Firestopping."

I. Bond shields and drain conductors to ground at only one point in each circuit.

J. Connect components to wiring system and to ground as indicated and instructed by manufacturer.

K. 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.

L. Identify cables according to Division 16 Section "Electrical Identification."

M. The contractor shall perform all terminations at the origination and outlet end. The contractor shall supply all cable and termination equipment. All cables shall be labeled with a unique ID for each cable with corresponding labels at the origination point (closet) and faceplate (station). All cables shall be bundled neatly, tie wrapped, and dressed into the termination panels. Origination (closet) and termination (station) points shall be identified by MMC on the project prints.

N. One 4-pair Category 3 UTP cable (refer to specification 16715) and one 4-pair Category 5-E UTP cable shall be installed at each location with a minimum of 10 feet of slack for a service loop both at the closet in a tray and at the station end in a secured coil.

O. All cable shall be placed along established cable pathways without weaving between pipes, conduit, etc. All direction changes shall be at ninety (90) degree angular turns. Consult the BICSI Telecommunications Design Manual (TDM) for clarification of these requirements.

P. The data cable shall be terminated normally on the left most RJ45 jack. The right jack is left blank with the exception of video conferencing applications.

Q. For all Video Conference installations, there shall be one 4-pair Category 5-E UTP cable installed for each video conference unit. These cables shall be terminated on the standard data connections as indicated on the contract drawings.

R. The cable shall be dressed and tie wrapped along the cable path.

S. All cabling (including multi pair) shall be identified by printed labels, the cable range, as documented in contract documents. This must be done on both ends of the cable as well as at each side of any penetration point and numbers shall be retained on the cable sheath after termination. All 4 pair station cables shall be treated in the same manner using the defined station number indicated on the master plan.

T. Use one 4-pair Berktek Category 5-E yellow Plenum, UTP cable for LAN data for Plenum applications. Horizontal lengths shall not exceed 100 meters from the origination point.

U. All data cables shall be terminated into approved Ortronics components at the station ends. NOTE: All Part Numbers are listed in Appendix A.

V. All riser cabling shall be run in a separate conduit. Conduit shall be sized to allow free movement of the riser cable depending on pair counts and O.D. of cable. Riser cable shall be pulled and terminated according to EIA/TIA specifications and labeled as outlined in the specifications with the corresponding cable number and origination point (from-to) at each end as well as all penetration points. NOTE: All Part Numbers are listed in Appendix A.

W. All Grounding installations shall be in accordance with all State and Federal regulations and shall follow any and all NEC,EIA/TIA, and BICSI Standards. Refer to contract drawings for additional information.

3.3 FIBER OPTIC CABLING

A. The contractor shall perform all terminations, at the origination and station end. Cable and termination equipment to be supplied by the contractor. All cables shall be labeled with a unique ID for each cable with corresponding labels at the origination point and faceplate and each side of all penetration points. All cables shall be bundled neatly, tie wrapped, and dressed into the termination panels. Origination (closet) and termination (station) shall be identified on the project prints.

B. All fiber and innerduct shall be labeled with the corresponding cable number and origination point (from-to) at each end as well as all penetration points.

C. All cable shall be installed inside appropriately sized innerduct, bright orange in color, sized appropriately for the number of strands requested and secured according to industry standards. Fiber cabling and innerduct that is run through machine areas shall be installed inside conduit for protection. All fiber conduits shall be marked "Fiber Optic Cable" every 10 feet on the conduit and at every penetration point.

D. All fiber installed for risers shall be rated for that application whether PVC or Plenum rated. Fiber innerduct shall be installed within riser conduit. Riser conduit shall be labeled "Fiber Optic Cable" every 10 feet in visible areas and at every penetration point.

E. All fiber shall be terminated with the Siecor SC connectors using the required tools and consumables. Siecor patch panels and connector centers shall be provided and installed by the contractor. NOTE: All Part Numbers are listed in Appendix A.

F. All fiber optic cables must be labeled with fiber optic warning tags within 18" of entering any light interface unit. All tags must show the fiber type, size, construction, and its source and destination locations. This information must also be included on each Fiber Optic Enclosure and on all link certification forms showing dB losses. All strands must be terminated in order of color code and properly labeled.

G. Manufacturer's material, equipment, and part numbers must be provided for all fiber optic materials. This includes light interface units, ST & SC connectors, fiber optic cable, color code, and construction of the cable.

H. Whenever strands are not terminated for any reason, those strands must be noted in the documentation with the location and future termination instructions included. All strands that are not terminated must be labeled anyway by marking the buffer to the main cable or each individual strand. These labels must coincide with the normal labeling scheme and must be noted in the documentation as unterminated strands.

3.4 VIDEO APPLICATIONS

A. Cabling for ITV, OBTV, and physiological monitoring systems and other electronic equipment shall conform to the following.

B. The contractor shall perform all terminations, at the origination and station ends. Cable and termination equipment to be supplied by the contractor.

C. All cables shall be labeled with a unique ID for each cable with corresponding labels at the origination point, destination point and on each side of any penetration point. This numbering sequence shall be the (To/From locations and Individual Room #'s that are being fed).

D. All cables shall be bundled neatly, tie wrapped, and dressed into the termination panels. Origination (closet) and termination (station) points shall be identified on the project prints. Final connection to the live system shall be performed by MMC.

E. All ITV outlet jacks shall be installed at the height of 96" unless otherwise noted on the contract drawings. Adequate blocking for TV support is required and shall be noted on the as-built documentation.

F. Terminations: Numerous connectors and adapters are available for each individual application. All outlets shall have a 2-1/2", 2" x 4" duplex box or a 2-½", 4" x 4" quad box.

MFG.	Part #	Description
TF	2360V	RG-6 CATV UL
TF	2362V	RG11-CATV UL
TF	7065ALC	RG-6 Plenum
TF	8118AL	RG-11 Plenum
HA	J30BF-F	F-F 30" Jumper Black
BT	CRT-(*)	One Port Tap/Directional Coupler
Pico	DC2G-(*)	Two Port Tap
Pico	DC4G-(*)	Four Port Tap
BT	XRS-2	2 Way Splitter
BT	XRS-4	4 Way Splitter
BT	XRS-8	8 Way Splitter
BT	F56-234	RG-6 Connector
GIL	GF-11-AH-S/460	Gilbert RG-11 Connector
BT	F56P	RG6 Plenum Connector
GIL	F11P	RG-11 Plenum Connector
BT	F81	F-F Splice Female/Female Barrel
BT	F-59T	75 Ohm Terminator
BT	FAM-(*)	Assorted Attenuator
BT	BITA 450-50	Distribution Amp
BT	BITA-RF	Return Filter
BT	BITA-RA	Return Amp
BT	BITA-CE-4	Cable Equalizer

BT	BITA-FA-(*)	Amplifier Attenuator
Pico	SC-3	Channel 3 VCP/VCR Inserter
HA	MCO1/4-F	TV Outlet w/Control Cable Jack (No cover Plate)
HA	JK1/4-PLT	Pillow Speaker Jack w/Single Gang St. Steel Plate
HA	WP-81SS	Stainless Steel Face Plate With "F" Barrel
HA	WP-81IV	Ivory Pace Plate w/"F" Barrel

BT= Blonder Tongue, Pico=Pico Macon, TF=Times Fiber, GIL=Gilbert, HA=Howlands Associates

Product Number	Description
#555650-1	AMP Duplex faceplate
#555670-1	AMP Quad Faceplate
#555621-1	AMP Unshielded Installation Kit
#555645-1	AMP 75ohm F series insert
#GF6AHSUSA	Gilbert RG-6 "F" Connector
#555642-1	AMP Video BNC insert
#555644-1	AMP Blank insert

G. As-Built documentation of any additions to the existing ITV plant shall be the responsibility of the contractor. All testing of the cabling plant shall be the responsibility of the contractor. Testing results shall be submitted to and approved by MMC prior to acceptance of any cabling work. As-Built drawings as well as floor by floor information are available for reference use by contacting the Engineering department.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing agency to perform field quality-control testing.

B. Copper Cable Testing Procedures: Inspect for physical damage and test cable for continuity, polarity, and shorts. Use time-domain reflectometer with strip-chart recording capability and anomaly resolution to within 12 inches (300 mm) in runs up to 1000 feet (300 m) in length. Test cable segments for faulty connectors, splices, terminations, and the integrity of the cable and its component parts.

C. Optical Fiber Cable Testing Procedures: Perform each visual and mechanical inspection and field test, including optional procedures, stated in NETA ATS, Section 7.25 except as superseded or made redundant by the following. Certify compliance with test parameters and manufacturer's written instructions.

1. All fiber optic strands must be tested in the following manner: All testing must be done using a fiber optic test meter such as Agilent WireScope 350, Fluke or OTDR. All multimode fiber strands must be tested at the 850nm and 1300nm wavelengths and in both directions and all singlemode fiber strands must be tested at the 1310nm and 1550nm wavelengths and in both directions. OTDR testing may be requested in one direction, from the equipment main location to the IDF location. All fiber strands shall be certified with no more than 2 dB of loss. All dB losses must be stated at both the 850 and 1300nm windows for the multimode and 1310nm and 1550nm wavelengths for the singlmode. All fiber facilities shall be tested in accordance with industry procedures. Link certification forms for each strand showing dB losses in both directions must be provided prior to acceptance. Any strands not passing the above tests shall not be accepted and shall be rerun at the contractor's expense.
2. All fiber test sheets and certification forms showing each strand tested from the MDF or main equipment location towards the IDF or secondary equipment location must be provided.

D. Any pairs that do not pass shall be reterminated and retested. If unable to repair any pair within a riser system they must be clearly marked as a bad pair by blacking out the color code on the 110 or BIX block and listing on the designation strip as B/P. Hard copy documentation shall be provided to the Cable Management Technician to make MMC aware that the pairs are not in a usable condition. MMC will not be held responsible for costs associated with bad pairs.

E. If cabling is to be used for high speed Token Ring or Ethernet connectivity, a twisted pair cable analyzer such as an AGILENT WireScope 350 ,OmniScanner, PentaScanner or Fluke DSP-150 or equivalent tester capable of measuring attenuation, NEXT, FEXT at frequencies up to 150+ MHz shall be used. These devices shall be capable of measuring cable length, NEXT, attenuation, ambient noise, and other important cable functions. When these tests are performed all results must be documented. Any cables not passing the above tests shall not be accepted and shall be rerun at the contractor's expense.

F. Replace malfunctioning cables at Project site, where possible, and retest to demonstrate compliance.

Appendix A

Product List and General Description
Data

Product Number	Description
40604-001	Chatsworth rack install kit (concrete)
40607-001	Chatsworth rack installation kit (wood)
55053-503	Chatsworth 19" Universal Rack (Clear)

55053-703	Chatsworth 19" Universal Rack (Black)
12096-503	Chatsworth Vertical Section (Clear)
12096-703	Chatsworth Vertical Section (Black)
10250-009	9" Universal Cable Runway (Gray)
10250-709	9" Universal Cable Runway (Black)
10250-012	12" Universal Cable Runway (Gray)
10250-712	12"Universal Cable Runway (Black)
OR-851004862	Ortronics 568A 24 port UTP patch panel
OR-851004865	Ortronics 568A 48 port UTP patch panel
OR-808044916	Ortronics wire management panel
OR-60400426	Ortronics wire management panel (Primary)
OR-60400199	Ortronics Strain Relief Bar
OR-62750002	568A dual RJ45 Jacks (DATA)
OR-40300182	Single gang face plates
OR-40300183	Dual gang face plates
OR-40700072	1.59 cm medium bezel for cubicles
043-0006-IV	DEK Wiremold .75"
042-0006-IV	DEK Wiremold 1.5"

Station Cable

Product Number	Description
232441--TP	Berktek 4 Pair Category 5-E Data (PLENUM)

Riser Cable

The following manufacturers provide an acceptable Multipair Riser cable product for use throughout the Maine Medical Center campus. Each manufacturer noted below may provide any of the mulitipair cables noted in the description field below. Prior to any installations, All vendors shall provide Maine Medical Center's Telecommunications Department with the complete Manufactuers specifications for the intended product.

Manufactuer	Description
Ortronics	25 Pair
Berk-Tek	50 Pair
General	100 Pair
Superior	200 Pair
Mohawk	300 Pair
Essex	400 Pair

FIBER OPTIC CABLE

Siecor Number	Description
#CCH-01U	24 port Closet Connector Housing
#CCH-02U	48 port Closet Connector Housing
#CCH-03U	72 port Closet Connector Housing
#WCH-02P	24 port Closet Connector Housing

#WCH-04P	48 port Closet Connector Housing
#CCH-CP06-15T	ST Multimode Connector Panel
#CCH-CP06-19T	ST Singlemode Connector Panel
#CCH-CP12-91	SC Multimode Connector Panel
#CCH-CP12-59	SC Singlemode Connector Panel
#95-000-41	SC Multimode Connector
#95-200-41	SC Singlemode Connector
#95-000-51	ST Multimode Connector
#95-200-51	ST Singlemode Connector
#CCH-BLNK	Blank Connector Panel

Siecor FREEDM Cable or Equivalent (**Corning Glass**)
Siecor MIC Cable or Equivalent (**Corning Glass**)

END OF SECTION 16121

SECTION 16124 - 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 1 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 SUBMITTALS

A. Product Data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.

B. Samples: 16-inch (400-mm) lengths of each type of cable indicated.

C. Qualification Data: For testing agency.

D. Source quality-control test reports.

E. Material Certificates: For each cable and accessory type, signed by manufacturers, certifying that cables comply with requirements specified in Part 2 Article "Source Quality Control."

F. Field quality-control test reports. All test results shall be submitted on NETA forms. The independent testing contractor shall prepare and submit, a bound test report. The test report shall indicate the following:

1. Date and time of test.
2. Test equipment used and serial numbers.
3. Tests performed.
4. Individual performing test.
5. Cable manufacturer, sizes, type, etc.
6. Cable length and end points.
7. Results of tests.
8. Manufacturer's recommended values.
9. Remarks and conclusions.

1.4 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: In addition to the requirements specified in Division 1 Section "Quality Control," MET Electrical Testing of Baltimore, MD shall perform independent testing.

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.

1.5 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect at least one week in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.

B. The distance noted between manholes is estimated and the Contractor shall be responsible to verify all distances. When computing cable quantity include diameter of existing manholes. Provide slack length of cable for each phase in each manhole.

C. Verify proper phase rotation on primary feeders prior to making connections.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cables

a. Okonite Company (The).
b. Rome Cable Corporation.

2. Cable Splicing and Terminating Products and Accessories:

a. Raychem Corp.; Telephone Energy and Industrial Division.
b. Thomas & Betts/Elastimold.
c. 3M Company; Electrical Products Division.

2.2 CABLES

A. Cable Type: Single Conductor, MV-105.

B. Conductor: Copper.

C. Conductor Stranding: Concentric lay, Class B.

D. Ethylene-propylene rubber complying with ICEA S68-516, AEIC CS 6, and NEMA WC 8.

1. Voltage Rating: 5 kV and 15 kV, as indicated on drawings.
2. Insulation Thickness: 133 percent insulation level.

E. Shielding: 5 mil copper tape helically applied (25 percent nominal overlap) over semi-conducting insulation shield.

F. Cable Jacket: Sunlight-resistant PVC.

G. Manufacturer Cable Identification: Every 2 feet of cable shall be identified with the voltage, size, material, insulation type and thickness, and manufacturer.

H. Cables shall comply with Underwriters Laboratories (UL) Standard 1072.

I. The general construction of the cable and the insulation material used shall be similar to that used for cable of the same size and rating in continuous production for at least fifteen years and successfully operating in the field in substantial quantities.

J. Cables shall be able to operate continuously at 105 degrees C conductor temperature, with an emergency rating of 140 degrees C and a short circuit rating of 250 degrees C. Emergency overloads shall be possible for periods of up to 100 hours. Five 100 hours emergency overload operations within the lifetime of the cable shall be possible.

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.

2.4 SOLID TERMINATIONS

A. 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.

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. 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.

D. 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.

E. 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- (250-micrometer-) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

B. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, compatible with cable jacket.

C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2 inch (13 mm) wide.

2.7 SOURCE QUALITY CONTROL

A. Test and inspect cables according to NEMA WC 8 before shipping.

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. Before any wires or cables are drawn into conduits, the conduit shall be cleaned out by pulling a swab or mandrel through the conduit with fish tape, and cables shall be pulled through conduit in such a manner as to avoid kinking or injuring the insulation.
2. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.

3. 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. Where feeders consisting of more than one conductor per phase pass through pull boxes or panels, each conductor of one phase shall be grouped together with the conductors of the other two phases to reduce reactance effect. Parallel circuit conductors shall be of equal length. Cables installed in same duct shall be pulled in together as a unit.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

E. 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.

F. Install cable splices at pull points and elsewhere as indicated; use standard kits.

G. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits.

H. 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:

1. Clean cable sheath.
2. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
3. Smooth surface contours with electrical insulation putty.
4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
5. Band arc-proofing tape with 1-inch- (25-mm-) wide bands of half-lapped, adhesive, glass-cloth tape 2 inches (50 mm) o.c.

I. Seal around cables passing through fire-rated elements according to Division 7 Section "Firestop and Smokeseals."

J. 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.

K. Identify cables according to Division 16 Section "Electrical Identification."

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage MET Electrical Testing of Baltimore, MD to perform field quality-control testing.

B. Testing: Perform the following field quality-control testing:

1. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.3.2. Certify compliance with test parameters.

C. Remove malfunctioning units, replace with new units, and retest as specified above.

END OF SECTION 16124

SECTION 16130 - RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 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 7 Section "Firestopping" for firestopping materials and installation at penetrations through walls, ceilings, and other fire-rated elements.
   2. Division 16 Section "Basic Electrical Materials and Methods" for supports, anchors, and identification products.
   3. Division 16 Section "Seismic Controls for Electrical Work" for seismic restraints and bracing of raceways, boxes, enclosures, and cabinets.
   4. Division 16 Section "Wiring Devices" for devices installed in boxes and for floor-box service fittings.

1.3 DEFINITIONS

A. GRSC: Galvanized Rigid Steel Conduit.

B. EMT: Electrical metallic tubing.

C. ENT: Electrical nonmetallic tubing.

D. FMC: Flexible metal conduit.

E. LFMC: Liquidtight flexible metal conduit.

F. LFNC: Liquidtight flexible nonmetallic conduit.

G. RNC: Rigid nonmetallic conduit.

H. SS: Stainless Steel

1.4 SUBMITTALS

A. Product Data: For all raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: Show fabrication and installation details of components for raceways, fittings, boxes, enclosures, and cabinets.

C. Shop Drawings: Signed and sealed by a qualified professional engineer.

1. Design Calculations: Calculate requirements for selecting seismic restraints.
2. Detail assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

D. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:

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, and special moldings.

E. Manufacturer Seismic Qualification Certification: Submit certification that enclosures, cabinets, accessories, and components will withstand seismic forces defined in Division 16 Section "Seismic Controls for Electrical Work." 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 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.

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.

1.6 COORDINATION

A. Coordinate layout and installation of raceways, boxes, enclosures, cabinets, and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

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 METAL CONDUIT AND TUBING

A. Manufacturers:

1. Rigid Metal Conduit:
   a. Triangle.
   b. National.
   c. Wheatland Tube Co.
   d. Grinnell Co./Tyco International; Allied Tube and Conduit Div.

2. Flexible Metal Conduit:
   a. American Flex Conduit.
   b. Alflex

3. Liquid Tight Flexible Metal Conduit:
   a. Anaconda Type UA.
   b. Electri-Flex Type LA.
   c. Flexi-Guard

4. Surface Metal Raceway:

   a. Wiremold

B. Galvanized Rigid Steel Conduit: ANSI C80.1.

C. EMT and Fittings: ANSI C80.3.

1. Fittings: Steel, set-screw type.
2. All EMT box connectors to be "insulated throat" type.

D. FMC: Zinc-coated steel.

E. LFMC: Flexible steel conduit with PVC jacket.

F. Fittings: NEMA FB 1; compatible with conduit and tubing materials.

2.3 NONMETALLIC CONDUIT AND TUBING

A. Manufacturers:

1. Lamson & Sessions; Carlon Electrical Products.
2. RACO; Division of Hubbell, Inc.
3. Spiralduct, Inc./AFC Cable Systems, Inc.
4. Thomas & Betts Corporation.

B. ENT: NEMA TC 13.

C. RNC: NEMA TC 2, Schedule 40 and Schedule 80 PVC.

D. ENT and RNC Fittings: NEMA TC 3; match to conduit or tubing type and material.

E. LFNC: UL 1660.

2.4 METAL WIREWAYS

A. Manufacturers:

1. Hoffman.
2. Square D.
3. Keystone/Rees, Inc.

B. Material and Construction: Sheet metal sized and shaped as indicated, NEMA 1 or 3R as required.

C. 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.

D. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

E. Wireway Covers: Screw-cover type.

F. Finish: Manufacturer's standard enamel finish.

2.5 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with snap-on covers. Finish with manufacturer's standard prime coating.

1. Manufacturer[s]:

a. Thomas & Betts Corporation.
b. Walker Systems, Inc.; Wiremold Company (The).
c. Wiremold Company (The); Electrical Sales Division.

B. Types, sizes, and channels as indicated and required for each application, with fittings that match and mate with raceways.

2.6 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers:

1. Hubbell, Inc.; Killark Electric Manufacturing Co.
2. Hoffman.
3. Emerson /General Signal; Appleton Electric Company.
4. O-Z/Gedney; Unit of General Signal.
5. RACO; Division of Hubbell, Inc.
6. Steel City Electrical Manufacturing Co.
7. Thomas & Betts Corporation.
8. Keystone.

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, Type FD, with gasketed cover.

D. Floor Boxes: Cast metal, fully adjustable, rectangular with brass finish.

E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

F. Cast-Metal Pull and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.

G. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.

H. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.

2.7 FACTORY FINISHES

A. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard paint applied to factory-assembled surface raceways, enclosures, and cabinets before shipping unless otherwise required by architect.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors:

1. Exposed: Galvanized Rigid steel.
2. Concealed: Galvanized Rigid steel.
3. Underground, Single Run: RNC, encased in concrete.
4. Underground, Grouped: RNC, encased in concrete.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
6. Boxes and Enclosures: NEMA 250, Type 3R or 4 as required.

B. Indoors:

1. Exposed: EMT or IMC.
2. Concealed: EMT or IMC.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC; except use LFMC in damp or wet locations.
4. Underground: RNC encased in concrete or embedded in slab. RGSC for conduit in slab for branch circuits serving patient care areas.
5. Damp or Wet Locations: GRSC.
6. Hazardous locations: GRSC with installation in accordance with the NEC.
7. Boxes and Enclosures: NEMA 250, Type 1, except as follows:

    a. Damp or Wet Locations: NEMA 250, Type 4, stainless steel.

C. Minimum Raceway Size: **3/4-inch trade size (DN 21).**

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

E. Do not install aluminum conduits embedded in or in contact with concrete.

3.2 INSTALLATION

A. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

B. Complete raceway installation before starting conductor installation.

C. Support raceways as specified in Division 16 Section "Basic Electrical Materials and Methods."

D. Install temporary closures to prevent foreign matter from entering raceways.

E. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above the finished slab.

F. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and keep straight legs of offsets parallel, unless otherwise indicated.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

1. Install concealed raceways with a minimum of bends in the shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.

H. Raceways Embedded in Slabs: Install in middle 1/3 of slab thickness where practical and leave at least 2 inches (50 mm) of concrete cover.

1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
2. Space raceways laterally to prevent voids in concrete.
3. Run conduit larger than 1-inch trade size (DN 27) parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
4. Nonmetallic tubing is not permitted in for branch circuits serving patient care areas.
5. Change from nonmetallic tubing to rigid steel conduit before rising above the floor.

I. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.

1. Run parallel or banked raceways together on common supports.

2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.

J. Join raceways with fittings designed and approved for that purpose and make joints tight.

1. Use insulating bushings to protect conductors.

K. Tighten set screws of threadless fittings with suitable tools.

L. Terminations:

1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.
2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.
3. Suitable fittings (i.e. Myers type hubs) shall be used in exterior applications to maintain NEMA weather tight rating of applicable enclosure.

M. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.

N. Telephone and Signal System Raceways, 2-Inch Trade Size (DN 53) and Smaller: In addition to above requirements, install raceways in maximum lengths of 150 feet (45 m) and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements.

O. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with UL-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. As required for conduits serving areas with hazardous classifications.
3. Where otherwise required by NFPA 70.

P. Stub-up Connections: Extend conduits through concrete floor for connection to free-standing equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches (150 mm) above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.

Q. Flexible Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in damp or wet locations. Install separate ground conductor across flexible connections.

R. Surface Raceways: Install a separate, green, ground conductor in raceways from junction box supplying raceways to receptacle or fixture ground terminals.

S. Set floor boxes level and flush with finished floor surfaces.

T. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

3.3 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.

3.4 CLEANING

A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.

END OF SECTION 16130

SECTION 16140 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Single and duplex receptacles, ground-fault circuit interrupters.
2. Single- and double-pole snap switches and dimmer switches.
3. Device wall plates.
4. Floor service outlets, poke-through assemblies, and multioutlet assemblies.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. PVC: Polyvinyl chloride.

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 pre-marking wall plates.

C. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device 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. 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 below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide one additional receptacle for every 25 installed.
2. Provide one additional switch for every 25 installed.
3. Provide one additional dimmer for every 10 installed.
4. Floor Service Outlet Assemblies: One for every 10, but no fewer than 10.
5. Poke-Through, Fire-Rated Closure Plugs: One for every five floor service outlets installed, but no fewer than 10.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Wiring Devices:

a. Hubbell Incorporated; Wiring Device-Kellems.
b. Leviton Mfg. Company Inc.

2. Multioutlet Assemblies:

a. Hubbell Incorporated; Wiring Device-Kellems.

b. Wiremold Company (The).

3. Poke-Through, Floor Service Outlets:

a. Hubbell Incorporated; Wiring Device-Kellems.
b. Square D/Groupe Schneider NA.
c. Wiremold Company (The).

2.2 RECEPTACLES

A. Straight-Blade-Type Receptacles: Comply with NEMA WD 1, NEMA WD 6, DSCC W-C-596G, and UL 498.

B. Straight-Blade Receptacles: Hospital grade.

C. Tamper Resistant Receptacles: Hospital grade tamper resistant receptacles.

D. GFCI Receptacles: Straight blade, non-feed-through type, Hospital grade, with integral NEMA WD 6, Configuration 5-20R duplex receptacle; complying with UL 498 and UL 943. Design units for installation in a 2-3/4-inch- (70-mm-) deep outlet box without an adapter.

E. Industrial Heavy-Duty Pin and Sleeve Devices: Comply with IEC 309-1.

F. Hazardous (Classified) Location Receptacles: Comply with NEMA FB 11.

2.3 SWITCHES

A. Single- and Double-Pole Switches: Comply with DSCC W-C-896F and UL 20.

B. Snap Switches: Heavy-Duty grade, quiet type.

1. Switches in the locations listed below shall be equipped with a clear, silicone rubber bubble plate to prevent shower spray from contacting energized components of the switch. Addition of bubble plate shall make switch assembly UL listed for wet location.

a. Second Floor Patient Toilet types A, B, C, D, E, F, G, H, I, J, and Patient Bathing.
b. Fourth Floor Patient Toilet types A, B, C, E, F, I, Q, and R.

C. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on/off switches and audible frequency and EMI/RFI filters.

1. Control: Continuously adjustable slider (slide to off); with single-pole or three-way switching to suit connections.

2. Incandescent Lamp Dimmers: Modular, 120 V, 60 Hz with continuously adjustable slider (slide to off); single pole with soft tap or other quiet switch; EMI/RFI filter to eliminate interference; and 5-inch (130-mm) wire connecting leads.
3. 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 10 percent of full brightness.

D. Momentary Contact Switches: Momentary contact, low-voltage, specification grade, side wired, three position, two circuit, center off.

1. Switch Operation: Switch shall operate patient bed light via low-voltage controller in sequential operation as follows:

a. Reading light "ON" / Ambient light "OFF"
b. Reading light "OFF" / Ambient light "ON"
c. Reading light "ON" / Ambient light "ON"
d. Reading light "OFF" / Ambient light "OFF"

2.4 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.

2.5 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: Smooth, high-impact thermoset nylon.
3. Material for Unfinished Spaces: Smooth, high-impact thermoset nylon.
4. Material for Food Prep Areas and Where Subject to Physical Damage: Stainless steel, non magnetic, satin finish.
5. Material for Wet Locations: Listed and labeled for use in "wet locations" while in use.

2.6 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 aluminum with dull chrome finish.

D. Power Receptacle: NEMA WD 6, Configuration 5-20R, hospital grade, unless otherwise indicated.

E. Voice and Data Communication Outlet: Blank cover with bushed cable opening.

2.7 POKE-THROUGH ASSEMBLIES

A. 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 two simplex receptacles and space for two 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 (75-mm)** 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 5 voice and data communication cables.

2.8 MULTIOUTLET ASSEMBLIES

A. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

B. Raceway Material: Metal, with manufacturer's standard finish.

2.9 FINISHES

A. Color:

1. Wiring Devices and Cover Plates Connected to Normal Power System: Ivory, unless otherwise indicated or required by NFPA 70.
2. Wiring Devices and Cover Plates Connected to Emergency Power System: Red.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install devices and assemblies level, plumb, and square with building lines.

B. Install receptacles with grounding slot down.

C. Wiring devices must be side wired, no back wiring is permitted.

D. Install wall dimmers to achieve indicated rating after derating for ganging according to manufacturer's written instructions.

E. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' written instructions.

F. 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.

G. Remove wall plates and protect devices and assemblies during painting.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 16 Section "Electrical Identification."

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 CONNECTIONS

A. Ground equipment according to Division 16 Section "Grounding and Bonding."

B. Connect wiring according to Division 16 Section "Conductors and Cables."

C. 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.

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing wiring devices and after electrical circuitry has been energized, test for proper polarity, ground continuity, and compliance with requirements.
2. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.

B. Remove malfunctioning units, replace with new units, and retest as specified above.

END OF SECTION 16140

SECTION 16145 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes time switches, photoelectric relays, and multipole lighting relays and contactors.

B. Related Sections include the following:

1. Division 16 Section "Wiring Devices" for wall-box dimmers and manual light switches.

1.3 SUBMITTALS

A. Product Data: Include dimensions and data on features, components, and ratings for lighting control devices.

B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

C. Maintenance Data: For lighting control devices to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain lighting control devices from a single source with total responsibility for compatibility of lighting control system components specified in this Section.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for their indicated use and installation conditions by a testing agency acceptable to authorities having jurisdiction.

C. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.

D. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate features of devices specified in this Section with systems and components specified in other Sections to form an integrated system of compatible components. Match components and interconnections for optimum performance of specified functions. Include coordination with the following:

1. Division 16 Section "Panelboards."

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:

1. Lighting Control Panels:

a. Square D Co.; Power Management Organization
b. Wattstopper.
c. GE Lighting Controls.
d. Automatic Switch Company

2. Photoelectric Relays:

a. Allen-Bradley/Rockwell Automation.
b. Intermatic, Inc.
c. Tork, Inc.

2.2 GENERAL LIGHTING CONTROL DEVICE REQUIREMENTS

A. Line-Voltage Surge Protection: Include in all 120- and 277-V solid-state equipment. Comply with UL 1449 and with ANSI C62.41 for Category A locations.

2.3 TIME SWITCHES

A. Description: Solid-state programmable units with alphanumeric display complying with UL 917.

1. Astronomic dial.

2. Two contacts, rated 30 A at 277-V ac, unless otherwise indicated.
3. Two pilot-duty contacts, rated 2 A at 240-V ac, unless otherwise indicated.
4. Eight-day program uniquely programmable for each weekday and holidays.
5. Skip-day mode.
6. Automatic adjustment for daylight savings.

2.4 PHOTOELECTRIC RELAYS

A. Description: Solid state, with single-pole, double-throw dry contacts rated to operate connected relay or contactor coils or microprocessor input, and complying with UL 773A.

B. Light-Level Monitoring Range: 0 to 3500 fc (0 to 37,673 lx), with an adjustment for turn-on/turn-off levels.

C. Time Delay: prevents false operation.

D. Outdoor Sealed Units: Weathertight housing, resistant to high temperatures and equipped with sun-glare shield and ice preventer.

2.5 LIGHTING CONTROL PANELS

A. Summary: Provide lighting control panel for line voltage control of interior and exterior lighting as indicated. System shall be complete with system clock, relays, contactors, etc. for a complete lighting control system. The system shall be structured as a multipanel system utilizing the same system clock and photocell inputs.

B. Time Switches.

1. Astronomic dial.
2. Two contacts, rated 30 A at 277-V ac, unless otherwise indicated.
3. Two pilot-duty contacts, rated 2 A at 240-V ac, unless otherwise indicated.
4. Eight channel, seven-day program uniquely programmable for each weekday and holidays.
5. Skip-day mode.
6. Automatic adjustment for daylight savings.
7. Battery backup.
8. Non volatile memory.

C. Multipole Contactors and Relays: Electrically operated and mechanically held, and complying with UL 508 and NEMA ICS 2.

1. Current Rating for Switching: UL listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballasts with 15 percent or less total harmonic distortion of normal load current).

2. Control Coil Voltage: Match control power source.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment level and plumb and according to manufacturer's written instructions.

B. Mount lighting control devices according to manufacturer's written instructions and requirements in Division 16 Section "Basic Electrical Materials and Methods."

C. Mounting heights indicated are to bottom of unit for suspended devices and to center of unit for wall-mounting devices.

3.2 CONTROL WIRING INSTALLATION

A. Install wiring between sensing and control devices according to manufacturer's written instructions and as specified in Division 16 Section "Conductors and Cables" for low-voltage connections.

B. Wiring Method: Install all wiring in raceway as specified in Division 16 Section "Raceways and Boxes," unless run in accessible ceiling space and gypsum board partitions.

C. Bundle, train, and support wiring in enclosures.

D. Ground equipment.

E. Connections: Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Division 16 Section "Electrical Identification."

3.4 FIELD QUALITY CONTROL

A. Schedule visual and mechanical inspections and electrical tests with at least seven days' advance notice.

B. Inspect control components for defects and physical damage, testing laboratory labeling, and nameplate compliance with the Contract Documents.

C. Check tightness of electrical connections with torque wrench calibrated within previous six months. Use manufacturer's recommended torque values.

D. Verify settings of photoelectric devices with photometer calibrated within previous six months.

E. Electrical Tests: Use particular caution when testing devices containing solid-state components. Perform the following according to manufacturer's written instructions:

1. Continuity tests of circuits.
2. Operational Tests: Set and operate devices to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.

    a. Include testing of devices under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

F. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

G. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

H. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.5 CLEANING

A. Cleaning: Clean equipment and devices internally and externally using methods and materials recommended by manufacturers, and repair damaged finishes.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

1. Train Owner's maintenance personnel on troubleshooting, servicing, adjusting, and preventive maintenance. Provide a minimum of three hours' training.
2. Training Aid: Use the approved final version of maintenance manuals as a training aid.
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.7 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested, to adjust light levels, make program changes, and adjust sensors and controls to suit actual conditions.

END OF SECTION 16145

SECTION 16271 - MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. The following Division 16 Specifications include coordination requirements with this Section:

1. "Switchgear."
2. "Medium Voltage Cables."
3. "Medium Voltage Switchgear."

1.2 SUMMARY

A. This Section includes the following types of transformers with medium-voltage primaries:
1. Dry-type distribution and power transformers.
2. Coordination of transformers with primary and secondary switchgear

1.3 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.

B. Shop Drawings: Wiring and connection diagrams including power wiring.

C. Coordination Drawings: Floor plans drawn to scale and coordinating floor penetrations and floor-mounted items. Show the following:

1. Underground primary and secondary conduit stub-up location.
2. Dimensioned concrete base, outline of transformer, and required clearances.
3. Ground rod and grounding cable locations.
4. Relationship with adjacent equipment including medium and low voltage switchgear.

D. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 16 Section "Seismic Controls for Electrical Work." 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 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.

E. Qualification Data: For testing agency.

F. Source quality-control test reports.

G. Field quality-control test reports.

H. Follow-up service reports.

I. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: MET Electrical Testing, Inc., of Baltimore, MD or approved equal independent testing 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. Product Options: Drawings indicate size, profiles, and dimensional requirements of Square D transformers and are based on the specific system indicated. Refer to Division 1 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. Comply with IEEE C2.

E. Comply with the following ANSI/IEEE Standards:
   1. ANSI C37.47

2. IEEE C57.12.00
3. IEEE C57.12.01
4. ANSI C57.12.26
5. ANSI C57.12.28
6. IEEE C57.12.51
7. IEEE C57.12.90
8. IEEE C57.12.91
9. IEEE C57.12.10
10. IEEE C57.12.70
11. IEEE C57.12.80.

F. Comply with NFPA 70 and ANSI C2.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store transformers protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

1.6 PROJECT CONDITIONS

A. Service Conditions: IEEE C37.121, usual service conditions.

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 3.

B. Coordinate installation of louvers, doors, spill retention areas, and sumps. Coordinate installation so no piping or conduits are installed in space allocated for medium-voltage transformers except those directly associated with transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D/Groupe Schneider NA.
2. General Electric.
3. ABB.

2.2 DRY-TYPE DISTRIBUTION AND POWER TRANSFORMERS

A. Description: NEMA ST 20, IEEE C57.12.01, ANSI C57.12.51, UL 1562 listed and labeled, dry-type, 2-winding transformers.

1. Indoor, ventilated cast coil, with copper primary and secondary 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.

2. Both high and low voltage windings shall be of copper conductors. Windings shall be separately cast as one rigid tubular coil, and arranged coaxially. Each cast coil shall be fully reinforced with glass cloth and cast under vacuum to provide complete void free resin impregnation throughout the entire insulation system. The coil supports shall maintain constant pressure during thermal expansion and contraction of the coils. There shall be no rigid mechanical connection between high and low voltage coils.

B. Primary Connection: Transition terminal compartment with connection pattern to match switchgear.

C. Secondary Connection: Transition terminal compartment with connection pattern to match low voltage switchgear.

D. Insulation Temperature Rise: 80 deg C, maximum rise above 40 deg C.

E. Basic Impulse Level: 95 kV.

F. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

G. Cooling System: Class AA, self-cooled, complying with IEEE C57.12.01.

H. Sound level may not exceed 68 dBA, without fans operating.

2.3 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 16 Section "Electrical Identification."

2.4 SEISMIC RESTRAINTS

A. Design and fabricate transformers, and anchorage devices for them, to withstand static and seismic forces in any direction.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to ANSI C57.12.51, IEEE C57.12.90, and IEEE C57.12.91.

B. Factory Tests: Perform the following factory-certified tests on each transformer:

1. Resistance measurements of all windings on rated-voltage connection and on tap extreme connections.
2. Ratios on rated-voltage connection and on tap extreme connections.
3. Polarity and phase relation on rated-voltage connection.
4. No-load loss at rated voltage on rated-voltage connection.
5. Excitation current at rated voltage on rated-voltage connection.
6. Impedance and load loss at rated current on rated-voltage connection and on tap extreme connections.
7. Applied potential.
8. Induced potential.

9. Owner retains the option to 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 conditions for compliance with requirements for medium-voltage transformers.

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 mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and that requirements in Division 16 Section "Grounding and Bonding" 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 transformers on concrete bases.

1. Anchor transformers to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 16 Section "Seismic Controls for Electrical Work."
2. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit and 4 inches (100 mm) high.
3. Use 3000-psi (20.7-MPa) 28-day compressive-strength concrete and reinforcement as specified in Division 3 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 (450-mm) centers around full perimeter of base.
5. Install epoxy-coated anchor bolts, for supported equipment, that extend through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

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 16 Section "Electrical Identification."

3.4 CONNECTIONS

A. Ground equipment according to Division 16 Section "Grounding and Bonding."

B. Connect wiring according to Division 16 Section "Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage MET Electrical Testing, Inc. of Baltimore, MD to perform the following field tests and inspections and prepare test reports:

B. Perform the following field tests and inspections and prepare test reports:

1. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.

2. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.2. Certify compliance with test parameters.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove malfunctioning units, replace with new units, and retest as specified above.

D. Test Reports: Prepare written reports 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 actions taken to achieve compliance with requirements.

3.6 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: If requested by Owner, perform the following voltage monitoring after Substantial Completion but not more than six months after Final Acceptance:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at secondary terminals of each transformer. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
2. Corrective Actions: If test results are unacceptable, perform the following corrective actions, as appropriate:

   a. Adjust transformer taps.
   b. Prepare written request for voltage adjustment by electric utility.

3. Retests: After corrective actions have been performed, repeat monitoring until satisfactory results are obtained.
4. Report: Prepare written report covering monitoring and corrective actions performed.

B. Infrared Scanning: Perform as specified in Division 16 Section "Medium-Voltage Switchgear."

END OF SECTION 16271

SECTION 16341 - MEDIUM-VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following medium-voltage switchgear, and associated auxiliary equipment.

1. Duplex switch rated 5 kV for emergency power unit substation.
2. Two single switches rated 15 kV for transformer primaries at unit substations.

B. Related Sections include the following:

1. Division 16 Section "Medium-Voltage Cables" for cable terminations at switchgear.
2. Division 16 Section "Medium Voltage Transformers" for close coupling to unit substation transformers.

1.3 SUBMITTALS

A. Product Data: For each component, including the following:
1. Features, characteristics, and ratings of individual interrupter switches.
2. Time-current characteristic curves for overcurrent protective devices.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Include the following:

1. Nameplate legends.
2. Bus configuration with size and number of conductors in each bus run, including phase, neutral, and ground conductors of main and branch buses.
3. Current ratings of buses.
4. Short-time and short-circuit ratings of switchgear assembly.
5. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where pipe and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

D. Product Certificates: Signed by manufacturers of switchgear certifying that the products furnished comply with requirements.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

F. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

G. Product Test Reports: Indicate compliance of switchgear with requirements.

H. Maintenance Data: For switchgear to include in the maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Engage a firm experienced in manufacturing switchgear similar to those indicated for this Project and with a record of successful in-service performance.

B. Testing Agency Qualifications: In addition to the requirements specified in Division 1 Section "Quality Control," an independent testing agency shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907; or shall be a full-member company of the InterNational Electrical Testing Association.

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 switchgear through one source from a single manufacturer.

D. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on specific system indicated. Other manufacturers' systems with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."

E. Comply with NFPA 70.

F. Comply with IEEE C2.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Store so condensation will not form on or in switchgear.

C. Apply temporary heat where required to obtain suitable service conditions.

D. Handle switchgear using factory-installed lifting provisions.

1.6 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than ten days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.

1.7 COORDINATION

A. Coordinate layout and installation of switchgear with other construction.

B. Coordinate size and location of concrete or mounting bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

1. Spare Fuses: Six, of each type and rating of fuse used. Include spares for power fuses, potential transformer fuses, control power fuses, and fuses and fusible devices for fused circuit breakers.
2. Spare Indicating Lights: Six, of each type installed.
3. Touchup Paint: Three containers of paint matching enclosure finish, each 0.5 pint (250 mL).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Metal-Enclosed Interrupter Switchgear:

   a. Square D Co.
   b. General Electric.

2.2 MANUFACTURED UNITS

A. Description: Factory assembled and tested, and complying with IEEE C37.20.1.

B. Product Selection for Restricted Space: Comply with maximum dimensions indicated on Drawings.

2.3 RATINGS

A. System Configuration: Switchgear suitable for application in three-phase, 60-Hz, grounded-neutral system.

   1. System Voltage: 4.16 kV nominal; 4.76 kV maximum.
   2. System Voltage: 13.2 kV nominal; 15 kV maximum.

2.4 METAL-ENCLOSED INTERRUPTER SWITCHGEAR AND PRIMARY SELECTOR SWITCH

A. Metal enclosed primary single switches for unit substations 13 and 14. configured for close coupling to each of the unit substations supplied in this package.

B. Metal enclosed primary duplex switch configured for close coupling to the emergency power unit substation.

C. Metal enclosed duplex selector switch for loop feed arrangement to existing substations 5 and 6.

D. The metal-enclosed switchgear shall be of indoor construction. The primary selector switch shall be a separate multiple section line-up. The sections shall contain the load interrupter switches and the necessary accessory components. The equipment shall be factory-assembled (except for necessary shipping splits) and operationally checked. The assembly shall be a self-supporting, floor mounted bay.

E. The substation 6 primary selector switch shall have front and side access only.

F. Comply with IEEE C37.20.3 and IEEE C37.20.4.

G. Ratings: Comply with standard ratings designated in IEEE C37.20.3 for the maximum-rated voltage specified.
   1. Main-Bus Continuous: 600 A.

H. Interrupter Switches: Stationary, gang operated, suitable for application to maximum short-circuit rating of integrated switchgear assembly.
   1. Rating: 600-A continuous duty and load break.
      a. Duty-Cycle, Fault Closing: 40,000 asymmetrical amperes.
   2. Switch Action: No external arc and no significant quantities of ionized gas released into the enclosure.
   3. Switch Construction: Supported entirely by interior framework of structure, with copper switch blades and stored-energy operating mechanism. Fixed mounted on NEMA class A-20 porcelain standoff insulators.
   4. Phase Barriers: Full length of blades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.
   5. Protective Shields: Cover live components and terminals.

I. Fuses: De-energized when switch is open.

J. Mechanical Interlock: Prevents opening switch compartment door unless switch blades are open, and prevents closing switch if door is open.

K. Window: Permits viewing switch-blade positions if door is closed.

L. Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include fuse-handling tool as recommended by switchgear manufacturer.

M. Power Fuses: Comply with applicable requirements of NEMA SG 2 and the following:
   1. Indicator: Integral with each fuse and shows when it has blown.
   2. Mounting: Fuses are positively held in position with provision for easy removal and replacement from the front without special tools.
   3. S&C Boric Acid fuses.
   4. Fuse sizes must be coordinated with results of system coordination study to ensure system coordination.

2.5 FABRICATION

A. Indoor Enclosure: Steel.

B. Finish: Manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.

2.6 COMPONENTS

A. Main Bus: Copper, silver plated at connection points.

B. Ground Bus: Copper, silver, or tin plated; minimum size 1/4 by 2 inches (6 by 50 mm); full length of switchgear.

C. Bus Insulation: Covered with flame-retardant insulation.

D. Surge Arresters: Distribution class, metal-oxide-varistor type. Comply with NEMA LA 1.

1. Install in cable termination compartments and connect in each phase of circuit.
2. Coordinate rating with circuit voltage.

2.7 IDENTIFICATION

A. Materials: Refer to Division 16 Section "Electrical Identification." Identify units, devices, controls, and wiring.

B. Materials: Refer to Division 16 Section "Basic Electrical Materials and Methods." Identify units, devices, controls, and wiring.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locations and Layout: Exact locations and physical layout of equipment and components may be varied as required to suit manufacturer's design and as approved, provided the required functions and operations are accomplished; follow the identification of the units indicated on Drawings exactly to ease checking and building maintenance procedures.

B. Anchor each switchgear assembly to at least two 4-inch (100-mm), channel-iron floor sills arranged according to the manufacturer's written recommendations; attach by tack welding or bolting.

1. Sills: Select to suit switchgear; level and grout flush into floor or concrete or mounting base.
2. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 2 inches (50 mm) in all directions beyond the maximum dimensions of the switchgear, unless otherwise indicated. Comply with Division 3 Section "Cast-in-Place Concrete."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear units and components.

3.2 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Division 16 Section "Electrical Identification."

B. Diagram and Instructions: Frame under clear acrylic plastic on the front of switchgear.

1. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
2. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of the maintenance manual.
3. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.

3.3 CONNECTIONS

A. Connect switchgear ground bus to common building ground indicated on Drawings.

B. Tighten bus joint, connector, and terminal bolts according to manufacturer's published torque-tightening values.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform the following field tests and inspections and prepare test reports:

B. Testing: After installing switchgear and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform inspections and tests specified below. Report values that do not meet manufacturer's written recommendations. Certify compliance with test parameters.
2. Switchgear: Perform inspections and tests stated in NETA ATS, Section 7.1.
3. Circuit Breakers: Perform inspections and tests stated in NETA ATS, Section 7.6.
4. Protective Relays: Perform inspections and tests stated in NETA ATS, Section 7.9.
5. Instrument Transformers: Perform inspections and tests stated in NETA ATS, Section 7.10.
6. Metering and Instrumentation: Perform inspections and tests stated in NETA ATS, Section 7.11.
7. Ground-Fault Systems: Perform inspections and tests stated in NETA ATS, Section 7.14.
8. Battery Systems: Perform inspections and tests stated in NETA ATS, Section 7.18.
9. Surge Arresters: Perform inspections and tests stated in NETA ATS, Section 7.19.
10. Capacitors: Perform inspections and tests stated in NETA ATS, Section 7.20.

C. Remove and replace malfunctioning units with new units and retest.

D. Infrared Scanning: After Substantial Completion, but not more than two months after Final Acceptance, perform an infrared scan of switchgear assembly. Make bus joints and connections accessible to a portable scanner and perform scanning during a period of normal working load as advised by Owner.

1. Follow-up Infrared Scanning: Perform one additional follow-up infrared scan at same locations as before, 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or detect significant deviations from normal values. Provide calibration record for scanning device used for electrical distribution equipment.
3. Record of Infrared Scanning: Prepare a certified report identifying all connections checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Fuse Characteristics: Verify that fuse size and types shown on Drawings are appropriate for final system configuration and parameters. Where discrepancies are found, recommend fuse selection for approval before making final adjustments.

3.6 CLEANING

A. Inspect interior and exterior of installed switchgear. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written recommendations, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel in the following:

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
2. Review data in the maintenance manuals. Refer to Division 1 Section "Contract Closeout."
3. Review data in the maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner with at least seven days' advance notice.

END OF SECTION 16341

SECTION 16410 - 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 Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes individually mounted enclosed switches and circuit breakers used for the following:

1. Feeder and branch-circuit protection.
2. Motor and equipment disconnecting means.
3. Elevator disconnecting means.

B. Related Sections include the following:

1. Division 16 Section "Wiring Devices" for attachment plugs, receptacles, and toggle switches used for disconnecting means.
2. Division 16 Section "Fuses" for fusible devices.

1.3 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. RMS: Root mean square.

C. SPDT: Single pole, double throw.

1.4 SUBMITTALS

A. Product Data: For each type of switch, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each switch and circuit breaker.

1. 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. Enclosure types and details for types other than NEMA 250, Type 1.
    b. Current and voltage ratings.
    c. Short-circuit current rating.
    d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that enclosed switches and circuit breakers, accessories, and components will withstand seismic forces defined in Division 16 Section "Seismic Controls for Electrical Work." Include the following:

1. Basis of 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 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: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.

E. Field Test Reports: Submit written test reports and include 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.

F. Manufacturer's field service report.

G. Maintenance Data: For enclosed switches and circuit breakers and for components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Closeout Procedures," include the following:

1. Routine maintenance requirements for components.

2. Manufacturer's written instructions for testing and adjusting switches and circuit breakers.
3. Time-current curves, including selectable ranges for each type of circuit breaker.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency 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 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 NEMA AB 1 and NEMA KS 1.

D. Comply with NFPA 70.

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 (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2000 m).

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. Spare Indicating Lights: Six of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Fusible Switches:

a. Square D Co.
b. General Electric Co.; Electrical Distribution & Control Division.

2. Molded-Case Circuit Breakers:

a. Square D Co.
b. General Electric Co.; Electrical Distribution & Control Division.

3. Molded-Case, Current-Limiting Circuit Breakers:

a. Square D Co.
b. General Electric Co.; Electrical Distribution & Control Division.

2.2 ENCLOSED SWITCHES

A. Enclosed, Nonfusible Switch: NEMA KS 1, Type HD, with lockable handle.

B. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, with clips to accommodate specified fuses, lockable handle with two padlocks, and interlocked with cover in closed position.

2.3 ENCLOSED CIRCUIT BREAKERS

A. 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.
2. Transformer Primary and Secondary Circuit Breakers: Square D models FA, FC, KC, LA, or General Electric models TEHD, THEF, THQD, THFK, THJK, circuit breakers with equivalent time-current curves as approved; or electronic trip unit breakers.
3. Adjustable Instantaneous-Trip Circuit Breakers: For circuit breaker frame sizes 200 A and up to 400 A, magnetic trip element with front-mounted, field-adjustable trip setting.

4. Electronic Trip Unit Circuit Breakers: For circuit breaker frame sizes 400 A and larger, 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.

5. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity standard. Provide 30-mA trip sensitivity when used for equipment ground fault circuit interruption.

B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Mechanical style suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment; type HID for metal halide and high pressure sodium lighting fixtures.
3. 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.
4. Shunt Trip (where indicated): 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.

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. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2.5 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested enclosures before shipping.

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.

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

3.2 INSTALLATION

A. Comply with mounting and anchoring requirements specified in Division 16 Section "Seismic Controls for Electrical Work."

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification."

B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.4 CONNECTIONS

A. Install equipment grounding connections for switches and circuit breakers with ground continuity to main electrical ground bus.

B. Install power wiring. Install wiring between switches and circuit breakers, and control and indication devices.

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.5 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed switch, circuit breaker, component, and control circuit.
2. Test continuity of each line- and load-side circuit.

B. Testing Agency: Engage a qualified independent testing agency to perform specified testing.

C. Testing: After installing enclosed switches and circuit breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. 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.

D. 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.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 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 and circuit breakers checked and that 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, inspect interior and exterior of enclosures. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16410

SECTION 16415 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 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 switch with bypass isolation.
2. Remote annunciation system.

1.3 SUBMITTALS

A. Product Data: Include ratings and dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

B. Wiring Diagrams: Detail wiring for transfer switches and differentiate between manufacturer-installed and field-installed wiring. Show both power and control wiring.

C. 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.

D. Product Certificates: Signed by manufacturer certifying that products furnished comply with requirements and that switches have been tested for load ratings and short-circuit closing and withstand ratings applicable to units for Project.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

F. Field Test Reports: Indicate and interpret test and inspection results for compliance with performance requirements.

G. Maintenance Data: For each type of product to include in maintenance manuals specified in Division 1. Include all features and operating sequences, both automatic and manual. List all factory settings of relays and provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing emergency maintenance and repairs at Project site with an eight-hour maximum response time.

B. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or 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 (Level 3 or higher), to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain automatic transfer switch, bypass/isolation switch, nonautomatic transfer switch, remote annunciators, and remote annunciator and control panels through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for emergency service under UL 1008, by a testing agency acceptable to authorities having jurisdiction.

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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Transfer Switches:

a. Emerson Electric Co.; Automatic Switch Co. Subsidiary.
b. Russelectric, Inc.

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.

C. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels have communications capability matched with remote device.

D. Solid-State Controls: Repetitive accuracy of all settings is plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

E. Resistance to Damage by Voltage Transients: Components meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components meet or exceed voltage-impulse withstand test of NEMA ICS 1.

F. Neutral Terminal: switched and fully rated, unless otherwise indicated.

G. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6; UL 508, unless otherwise indicated.

H. 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.

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.

I. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

J. 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 greater have separate arcing contacts.

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 the same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. 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.

E. Digital Communications Interface: Matched to capability of remote annunciator or annunciator and control panel.

F. Programmed Neutral Switch Position for Equpment Branch Transfer Switches: 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.

2.4 AUTOMATIC TRANSFER-SWITCH FEATURES

A. Undervoltage Sensing for Each Phase of Normal Source: Senses low phase-to-ground voltage on each phase. Pickup voltage is 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.

B. Time delay for override of normal-source voltage sensing delays transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.

C. Voltage/Frequency Lockout Relay: Prevents premature transfer to generator set. Pickup voltage is adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency is adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

D. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes; factory set for 10 minutes. Provides automatic defeat of delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.

E. Test Switch: Simulates normal-source failure.

F. Switch-Position Pilot Lights: Indicate source to which load is connected.

G. Source-Available Indicating Lights: Supervise sources via transfer-switch, normal- and emergency-source sensing circuits.

1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
2. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

H. Unassigned Auxiliary Contacts: Two normally open single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.

I. 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.

J. Engine Starting Contacts: One isolated, normally closed and one isolated, normally open, rated 10 A at 32-V dc minimum.

K. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes; factory set for five minutes. Initiates shutdown at remote engine-generator controls after retransfer of load to normal source.

L. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine-generator set and transfers load to it from normal source for a preset time, then retransfers. 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:

1. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
2. Push-button programming control with digital display of settings.
3. Integral battery operation of time switch when normal control power is not available.

2.5 BYPASS/ISOLATION SWITCH FEATURES

A. Comply with requirements for Level 1 equipment per NFPA 110.

B. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:

1. Means to lock bypass/isolation in the position that isolates transfer switch, with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
2. Drawout Arrangement for Transfer Switch: Provides physical separation from live parts and accessibility for testing and maintenance operations.
3. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with the same phase arrangement and number of poles.
4. Contact temperatures of bypass/isolation switches do not exceed those of automatic transfer-switch contacts when they are carrying rated load.
5. Operability: Constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations in 15 seconds or less.
6. Legend: Manufacturer's standard legend for control labels and instruction signs give detailed operating instructions.
7. Maintainability: Fabricate to allow convenient removal of major components from the front without removing other parts or main power conductors.

C. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars, plated at connection points and braced for the indicated available short-circuit current.

2.6 REMOTE ANNUNCIATOR SYSTEM

A. Functional Description: Remote annunciator panel annunciates conditions for indicated transfer switches. Annunciation includes 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 communications 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.

2.7 FINISHES

A. Enclosures: Manufacturer's standard enamel over corrosion-resistant pretreatment and primer.

2.8 SOURCE QUALITY CONTROL

A. Factory Test 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 APPLICATION

A. Four-Pole Switches: Where four-pole switches are indicated, provide neutral switching.

3.2 INSTALLATION

A. Floor-Mounted Switch: Level and anchor unit to floor.

B. Annunciator and Control Panel Mounting: surface mounted, unless otherwise indicated.

C. Identify components according to Division 16 Section "Electrical Identification."

3.3 WIRING TO REMOTE COMPONENTS

A. Match type and number of cables and conductors to control and communications requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Provide generator start circuit from all transfer switches to associated generator control panel. Generator start circuit conductor size shall be sized to accommodate potential voltage drop due to length of circuit.

3.4 CONNECTIONS

A. Ground equipment as indicated and as required by NFPA 70.

3.5 FIELD QUALITY CONTROL

A. Testing: Engage a qualified testing agency to perform the following field quality-control testing:

B. Testing: Perform the following field quality-control testing under the supervision of the manufacturer's factory-authorized service representative in addition to tests recommended by the manufacturer:

1. Before energizing equipment, after transfer-switch products have been installed:

   a. 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. Meet manufacturer's specified minimum resistance.
   b. Check for electrical continuity of circuits and for short circuits.
   c. Inspect for physical damage; proper installation and connection; and integrity of barriers, covers, and safety features.
   d. Verify that manual transfer warnings are properly placed.
   e. Perform manual transfer operation.

2. 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 one 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 sequence.

C. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

1. Assist in verifying grounding connections and locations and ratings of sensors.
2. Assist in observing reaction of circuit-interrupting devices when simulated fault current is applied at sensors.

D. Coordinate tests with tests of generator plant and run them concurrently.

E. 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.

3.6 CLEANING

A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean equipment internally, on completion of installation, according to manufacturer's written instructions.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain transfer switches and related equipment as specified below:

1. Coordinate this training with that for generator equipment.
2. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
3. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
4. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
5. Schedule training with Owner, through Architect, with at least seven days' advance notice.
6. Provide a minimum of four hours of instruction.

END OF SECTION 16415

SECTION 16420 - ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes ac general-purpose controllers rated 600 V and less that are supplied as enclosed units.

B. Related Sections include the following:
   1. Division 16 Section "Fuses" for fuses in fusible switches.

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. 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. Enclosure types and details.
      b. Nameplate legends.
      c. Short-circuit current rating of integrated unit.
      d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.

   2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.

C. Coordination Drawings: Floor plans 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. Manufacturer Seismic Qualification Certification: Submit certification that enclosed controllers, accessories, and components will withstand seismic forces defined in Division 16 Section "Seismic Controls for Electrical Work." 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 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.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

F. Field Test Reports: Written reports specified in Part 3.

G. Manufacturer's field service report.

H. Maintenance Data: For enclosed controllers and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Closeout Procedures," include the following:

1. Routine maintenance requirements for enclosed controllers and all installed components.

I. 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.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent testing agency with the experience and capability to satisfactorily conduct the testing indicated, as documented according to ASTM E 548.

B. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer.

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.

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 subjected to weather, cover enclosed controllers to protect 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

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 3 Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 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 not less 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 the following:

1. Manual and Magnetic Enclosed Controllers:

a. Square D Co.
b. General Electrical Distribution & Control.

2.2 MANUAL ENCLOSED CONTROLLERS

A. Description: NEMA ICS 2, general purpose, Class A, with toggle action and overload element.

B. Projection Screen Controllers: Provide three position momentary contact switch for control of projection screens. Switch shall be configured as raise, lower, and center off.

2.3 MAGNETIC ENCLOSED CONTROLLERS

A. Description: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.

B. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

C. Combination Controller: Factory-assembled combination controller and disconnect switch.

1. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

D. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class 10 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.

E. Multispeed Enclosed Controller: Match controller to motor type, application, and number of speeds; include the following accessories:

1. Compelling relay to ensure 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.

F. Star-Delta Controller: NEMA ICS 2, closed transition with adjustable time delay.

G. Part-Winding Controller: NEMA ICS 2, closed transition with separate overload relays for starting and running sequences.

H. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition.

I. 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 ENCLOSURES

A. Description: Flush- or surface-mounted 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.
3. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

2.5 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.

2.6 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.

B. 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, drive, 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. See Division 16 Section "Basic Electrical Materials and Methods" for general installation requirements.

B. 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 16 Section "Basic Electrical Materials and Methods."

C. Install freestanding equipment on concrete bases complying with Division 3 Section "Cast-in-Place Concrete."

D. Comply with mounting and anchoring requirements specified in Division 16 Section "Seismic Controls for Electrical Work."

E. Enclosed Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 16 Section "Fuses."

3.4 IDENTIFICATION

A. Identify enclosed controller components and control wiring according to Division 16 Section "Electrical Identification."

3.5 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers according to Division 16 Section "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.

3.6 CONNECTIONS

A. Conduit installation requirements are specified in other Division 16 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment.

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.7 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed controller bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Testing: Engage a qualified testing agency to perform the following field quality-control testing:

1. Perform each electrical test and visual and mechanical inspection indicated in NETA ATS, Sections 7.5, 7.6, and 7.16.
2. 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.

C. 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.

3.8 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.9 CLEANING

A. Clean enclosed controllers internally, on completion of installation, according to manufacturer's written instructions. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.10 STARTUP SERVICE

A. Verify that enclosed controllers are installed and connected according to the Contract Documents.

B. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 16 Sections.

C. Complete installation and startup checks according to manufacturer's written instructions.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 16420

SECTION 16430 - SWITCHGEAR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes metal-enclosed, low-voltage, power circuit-breaker switchgear rated 1000 V and less for use in ac systems.

1. Normal power substations consist of a double ended switchgear lineup with a fully rated tie breaker. The transfer scheme is automatic and PLC controlled.
2. The emergency power switchgear is a single ended substation switchgear with no ground fault trip functions.

B. Related Sections include the following:

1. Division 16 Section "Seismic Controls for Electrical Work" for mounting and anchoring switchgear.
2. Division 16 Section "Medium Voltage Transformers" for interfacing unit substation requirements.

1.3 SUBMITTALS

A. Product Data: For each type of switchgear, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each type of switchgear and related equipment.

1. 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. Enclosure types and details.
b. Nameplate legends.
c. Bus configuration with size and number of conductors in each bus run, including phase, neutral, and ground conductors of main and branch buses.
d. Current rating of buses.

e. Short-time and short-circuit current rating of switchgear assembly.
f. Mimic-bus diagram.
g. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where pipe and ducts are prohibited. Show switchgear layout and relationships between 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 switchgear, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 16 Section "Seismic Controls for Electrical Work." Include the following:

1. Basis of 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 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.

E. Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.

F. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

G. Field Test Reports: Submit written test reports and include 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.

H. Manufacturer's field service report.

I. Updated mimic-bus diagram reflecting field changes after final switchgear load connections have been made, for record.

J. Maintenance Data: For switchgear and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Closeout Procedures," include the following:

1. Routine maintenance requirements for switchgear and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
3. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications:

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 switchgear through one source from a single manufacturer.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the GE and Square D metal clad switchgear.

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. Deliver switchgear in sections of lengths that can be moved past obstructions in delivery path.

B. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

1.6 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.

B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than seven days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions.
2. Indicate method of providing temporary utilities.
3. Do not proceed with utility interruptions without Architect's written permission.

C. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not exceeding 40 deg C.
2. Altitude: Not exceeding 6600 feet (2000 m).

1.7 COORDINATION

A. Coordinate layout and installation of switchgear and components with other construction that penetrates ceilings or is supported by them, including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.

B. Coordinate size and location of concrete bases. Coordinate sill placement in concrete bases.

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. Fuses: Six of each type and rating used. Include spares for potential transformer fuses, control power fuses, and fuses and fusible devices for fused circuit breakers.
2. Indicating Lights: Six of each type installed.
3. Touchup Paint: Three containers of paint matching enclosure finish, each 0.5 pint (250 mL).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D Co./Groupe Schneider NA.
2. General Electric

2.2 RATINGS

A. Nominal System Voltage: 480/277 V, 4 wire, 60 Hz.

B. Main-Bus Continuous: As indicated.

C. Short-Time and Short-Circuit Current: As indicated.

2.3 FABRICATION

A. Factory assembled and tested and complying with IEEE C37.20.1.

B. Listed to UL 1558

C. Comply with NFPA 70 requirements for Service Entrance.

D. Indoor Enclosure Material: Steel.

E. Finish: IEEE C37.20.1, manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.

F. Section barriers between main and tie circuit-breaker compartments shall be extended to rear of section.

G. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.

H. Circuit-breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors.

I. Breaker cells to be equipped with automatic shutters to provide isolation when breaker is removed.

J. Fabricate enclosure with removable, hinged, rear cover panels, secured by captive thumb-screws, to allow access to rear interior of switchgear.

K. Auxiliary Compartments: Match and align with basic switchgear assembly. Include the following:
1. Bus transition sections as required.
2. Hinged front panels for access to metering, accessory, and blank compartments.

L. Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.

1. Main Phase Bus: Uniform capacity the entire length of assembly.
2. Neutral Bus: 100 percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.
3. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
4. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
5. Use copper for connecting circuit-breaker line to copper bus.
6. Contact Surfaces of Buses: Silver plated.
7. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
8. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4 by 2 inches (6 by 50 mm).
9. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.
10. Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.
11. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.

2.4 COMPONENTS

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Ratios as required for current ratings; burden and accuracy class suitable for connected relays, meters, and instruments.

B. Multifunction Digital-Metering Monitor: UL-listed or -recognized, 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. Total harmonic distortion, current and voltage.
i. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
j. 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.

4. Control unit shall be capable of remote network monitoring.

C. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

D. Control Power Supply: Control power transformer supplying 120-V control circuits through secondary disconnect devices. Include the following features:
1. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.

a. Secondary windings connected through a relay or relays to control bus to effect an automatic transfer scheme.
b. Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.

2. Control Power Fuses: Primary and secondary fuses with current-limiting and overload protection.

E. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
2. Conductors sized according to NFPA 70 for the duty required.

2.5 CIRCUIT BREAKERS

A. Description: Comply with IEEE C37.13.

B. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.

C. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

1. Normal Closing Speed: Independent of both control and operator.
2. Slow Closing Speed: Optional with operator for inspection and adjustment.
3. Stored-Energy Mechanism: Electrically charged, with optional manual charging.
4. Operation counter.

D. Trip Devices (Normal Power Switchgear): Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:

1. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
2. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
3. Field-adjustable, time-current characteristics.
4. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
5. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
6. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I^2t operation.
7. Pickup Points: Five minimum, for instantaneous-trip functions.
8. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:

    a. Four-wire, double-ended substation with four wire and three wire feeder circuits.

9. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault. Trip unit shall provide local trip indication and capability to indicate local and remote reason for trip, e.g., overload, short circuit or ground fault.
10. Communications: Trip units communicate on hospital network, providing amperes and breaker status data for each feeder.

E. Trip Devices, Emergency Power Switchgear: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:

1. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
2. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
3. Field-adjustable, time-current characteristics.
4. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.

5. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
6. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I^2t operation.
7. Pickup Points: Five minimum, for instantaneous-trip functions.
8. Ground-fault alarm indication only, with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide visual alarm indication.
9. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault. Trip unit shall provide local trip indication and capability to indicate local and remote reason for trip, e.g., overload, short circuit.
10. Communications: Trip units communicate on hospital network, providing amperes and breaker status data for each feeder.

F. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two Type "a" and two Type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.

G. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:

1. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.
2. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed, unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:

    a. Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
    b. Disconnected Position: Primary and secondary devices and ground contact disengaged.

H. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.

I. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.

J. Operating Handle: One for each circuit breaker capable of manual operation.

K. Electric Close Button: One for each electrically operated circuit breaker.

L. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

M. The double ended substation made up of substations 13 and 14 shall be equipped with appropriate relays and a PLC controller to control main-tie-main transfer scheme. The normally open tie breaker shall be automatically operated in coordination with opening of associated main breaker upon loss of one of the incoming services. An appropriate time delay shall be incorporated to override main-tie-main transfer scheme of incoming utility service.

2.6 ACCESSORIES

A. Accessory Set: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

1. Racking handle to manually move circuit breaker between connected and disconnected positions.
2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.

B. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.

C. Spare-Fuse Cabinet: Identified and compartmented steel box, or cabinet with lockable door.

D. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

E. Transient Voltage Surge Suppressors: Where indicated provide transient voltage surge suppressors which are manufactured in accordance with IEEE C62.41, and are selected to meet requirements for category indicated. All surge transient voltage surge suppressors shall be UL 1449 Listed and shall be approved for the location in which they are installed.

1. Exposure: High.
2. Category C3.
3. Ratings: Three stage parallel device capable of supressing 240,000 amperes.
4. Maximum response time shall not exceed 1 nanosecond.
5. Provide a noise filtering system capable of managing noise levels produced by electro-magnetic interference and radio frequency interference. The system shall reject a minimum of 50dB as measured by the 50 Ohm Insertion Loss Method.
6. The system shall operate over a frequency range of 45 hertz to 450 hertz.

7. The system's filtering mode shall provide sinewave tracking to within plus or minus 20 percent.
8. Clamping voltage value of system shall be no greater than 1000 Volts.
9. Provide visual status indication as to the proper operation of the system. Provide a summary contact for remote monitoring of the system.

2.7 IDENTIFICATION

A. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram on an 11 x 17 phenolic inscribed nameplate.

B. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads. Include as-built data for low-voltage power switchgear and connections as follows:

1. Frame size of each circuit breaker.
2. Trip rating for each circuit breaker.
3. Conduit and wire size for each feeder.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive switchgear for compliance with installation tolerances and other conditions affecting performance.

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

3.2 INSTALLATION

A. Anchor switchgear assembly to 4-inch (100-mm), channel-iron sill and attach by bolting.

1. Sills: Select to suit switchgear; level and grout flush into concrete base.
2. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 2 inches (50 mm) in all directions beyond the maximum dimensions of switchgear, unless otherwise indicated. Cast sills into bases. Comply with Division 3 Section "Cast-in-Place Concrete."

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear units and components.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification."

B. Bus Diagram and Instructions: Frame and mount under clear acrylic plastic on the front of switchgear.

C. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.

3.4 CONNECTIONS

A. Install equipment grounding conductors for switchgear with ground continuity to main electrical ground bus.

B. Tighten bus joints, 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.

3.5 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Testing Agency: Engage a qualified independent testing to perform specified testing.

C. Testing: After installing switchgear and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Perform each electrical test and visual and mechanical inspection indicated in NETA ATS. Certify compliance with test parameters.

    a. Switchgear: Perform tests and inspections stated in NETA ATS, Section 7.1.
    b. Circuit Breakers: Perform tests and inspections stated in NETA ATS, Section 7.6.
    c. Protective Relays: Perform tests and inspections stated in NETA ATS, Section 7.9.
    d. Instrument Transformers: Perform tests and inspections stated in NETA ATS, Section 7.10.
    e. Metering and Instrumentation: Perform tests and inspections stated in NETA ATS, Section 7.11.
    f. Ground-Fault Systems: Perform tests and inspections stated in NETA ATS, Section 7.14.

g. Battery Systems: Perform tests and inspections stated in NETA ATS, Section 7.18.
h. Capacitors: Perform tests and inspections stated in NETA ATS, Section 7.20.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 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 switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Set field-adjustable, protective-relay trip characteristics.

3.7 CLEANING

A. On completion of installation, inspect interior and exterior of switchgear. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.9 STARTUP SERVICES

A. Engage a factory-authorized service representative to perform startup service.

B. Verify that switchgear is installed and connected according to the Contract Documents.

C. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 16 Sections.

D. Complete installation and startup checks according to manufacturer's written instructions.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear.

1. Train Owner's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 16430

SECTION 16441 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes service and distribution switchboards rated 600 V and less.

B. Related Sections include the following:
   1. Division 16 Section "Seismic Controls for Electrical Work."

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. RFI: Radio-frequency interference.

D. RMS: Root mean square.

E. SPDT: Single pole, double throw.

F. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, TVSS device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

   1. 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. Enclosure types and details for types other than NEMA 250, Type 1.
b. Bus configuration, current, and voltage ratings.
c. Short-circuit current rating of switchboards and overcurrent protective devices.
d. Descriptive documentation of optional barriers specified for electrical insulation and isolation.
e. Utility company's metering provisions with indication of approval by utility company.
f. Mimic-bus diagram.
g. UL listing for series rating of installed devices.
h. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 16 Section "Seismic Controls for Electrical Work." Include the following:

1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. The term "withstand" means "the unit will remain in place without separation of internal and external parts during a seismic event and the unit will be fully operational after the event."
3. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
4. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Samples: Representative portion of mimic bus with specified finish, for color selection.

E. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.

F. Field Test Reports: Submit written test reports and include 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.

G. Manufacturer's field service report.

H. Updated mimic-bus diagram reflecting field changes after final switchboard load connections have been made, for record.

I. Maintenance Data: For switchboards and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Contract Closeout," 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 curves, including selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency 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 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 NEMA PB 2.

D. Comply with NFPA 70.

E. 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.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver in sections of lengths that can be moved past obstructions in delivery path.

B. Store indoors in clean dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subjected to weather, cover switchboards to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchboards; install electric heating (250-W per section) to prevent condensation.

D. Handle switchboards according to NEMA PB 2.1.

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. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than seven days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions.
2. Indicate method of providing temporary utilities.
3. Proceed with utility interruptions only after receiving Architect's written authorizations.

C. Environmental Limitations: Rate equipment for continuous operation under the following, unless otherwise indicated:

1. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2000 m).

D. Service Conditions: NEMA PB2, usual service conditions, as follows:

1. Altitude not exceeding 6600 feet (2000 m).
2. Ambient temperatures within limits specified.

1.8 COORDINATION

A. Coordinate layout and installation of switchboards 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.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

1.9 EXTRA MATERIALS

A. Spares: For the following:

1. Potential transformer fuses.
2. Control-poser fuses.
3. Fuses and fusible devices for fused circuit breakers.
4. Fuses for fused switches.
5. fuses for fused power-circuit devices.

B. Spare Indicating Lights: Six of each type installed.

PART 2 - PRODUCT

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. General Electric Co.; Electrical Distribution & Control Div.
   2. Square D Co.

2.2 MANUFACTURED UNITS

A. Front-Connected, Front-Accessible Switchboard: draw out main device, individually-mounted branches, and sections rear aligned.

B. Front- and Side-Accessible Switchboard: Fixed, individually mounted main device, panel-mounted branches, and sections rear aligned.

C. Nominal System Voltage: **480Y/277 V** and **208 Y/120 V** .

D. Main-Bus Continuous: As indicated

2.3 FABRICATION AND FEATURES

A. Enclosure: Steel:

B. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

C. Barriers: Between adjacent switchboard sections.

D. Insulation and isolation for main and vertical buses of feeder sections.

E. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

F. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

G. Hinged Front Panels: Allow access to circuit-breaker, metering, accessory, and blank compartments.

H. Pull Box on Top of Switchboard: Include the following features:

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.

I. Buses and Connections: Three phase, four wire, unless otherwise indicated. Include the following features:

1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity with feeder circuit-breaker line connections.
2. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy with copper or tin-plated, aluminum circuit-breaker line connections.
3. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.

    a. If bus is aluminum, use copper or tin-plated aluminum for circuit-breaker line connections.
    b. If bus is copper, use copper for feeder circuit-breaker line connections.

4. Load Terminals: Insulated, rigidly braced, silver-plated, copper runback bus extensions equipped with pressure connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full ampere rating of circuit-breaker position.
5. Ground Bus: 1/4-by-2-inch (6-by-50-mm) minimum size, drawn-temper copper of 98 percent conductivity, equipped with pressure 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.
6. Contact Surfaces of Buses: Silver plated.
7. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
8. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
9. Neutral Buses: 100 percent of the ampacity of the phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus is braced.

J. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.4 TVSS DEVICES

A. IEEE C62.41, integrally mounted, plug-in style, solid-state, parallel-connected, sine-wave tracking suppression and filtering modules.

B. Minimum single-impulse current rating shall be as follows:

1. Line to Neutral: 100,000 A.
2. Line to Ground: 100,000 A.
3. Neutral to Ground: 50,000 A.

C. Protection modes shall be as follows:

1. Line to neutral.
2. Line to ground.
3. Neutral to ground.

D. EMI/RFI Noise Attenuation Using 50-ohm Insertion Loss Test: 55 dB at 100 kHz.

E. Category C combination wave clamping voltage shall not exceed **[600 V, line to neutral and line to ground on 120/208 V systems] [1000 V, line to neutral and line to ground on 277/480 V systems]**.

F. UL 1449 clamping levels shall not exceed **[400 V, line to neutral and line to ground on 120/208 V systems] [800 V, line to neutral and line to ground on 277/480 V systems]**.

G. Withstand Capabilities: 3000 Category C surges with less than 5 percent change in clamping voltage.

H. Accessories shall include the following:

1. Form-C contacts, one normally open and one normally closed, for remote monitoring of system operation. Contacts to reverse position on failure of any surge diversion module.
2. Audible alarm activated on failure of any surge diversion module.
3. Six-digit transient-counter set to totalize transient surges that deviate from the sine-wave envelope by more than 125 V.

2.5 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

1. 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 (Normal Power 480/277 Volt Switchboards Only), time delay, and I^2t response.

B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.

1. Lugs: **Mechanical** style, suitable for number, size, trip ratings, and material of conductors.
2. Ammeter display on electronic trip unit.
3. Application Listing: Appropriate for application; 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.
6. Auxiliary Switch: **[One SPDT switch] [Two SPDT switches]** with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b"contacts operate in reverse of circuit-breaker contacts.

2.6 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kV.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondaries to ground overcurrent relays 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. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from 5 to 60 minutes.
i. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent. Accumulated values unaffected by power outages up to 72 hours.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.7 CONTROL POWER

A. Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer.

B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. 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.

2.8 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: To test functions of solid-state trip devices without removal from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

2.9 IDENTIFICATION

A. 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. Coordinate mimic-bus segments with devices in switchboard sections to which applied. Produce a concise visual presentation of principal switchboard components and connections.

B. Presentation Media: Painted graphics in color contrasting with equipment factory-finished background to represent bus and components, complete with lettered designations.

PART 3 - EXECUTION

3.1 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.2 EXAMINATION

A. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance.

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

3.3 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Support switchboards on concrete bases, 4-inch (100-mm) nominal thickness.

C. Comply with mounting and anchoring requirements specified in Division 16 Section "Seismic Controls for Electrical Work."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

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.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section **"Electrical Identification."**

B. Switchboard Nameplates: Label each switchboard compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.5 CONNECTIONS

A. Install equipment grounding connections for switchboards with ground continuity to main electrical ground bus.

B. 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 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Testing Agency: Engage a qualified independent testing agency to perform specified testing.

C. Testing: After installing switchboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate. 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.

D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 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 switchboards checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.7 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.8 CLEANING

A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16441

SECTION 16442 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes load centers and panelboards, overcurrent protective devices, and associated auxiliary equipment rated 600 V and less for the following types:

1. Lighting and appliance branch-circuit panelboards.
2. Distribution panelboards..

B. Related Sections include the following:
1. Division 16 Section "Seismic Controls for Electrical Work."

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. RFI: Radio-frequency interference.

D. RMS: Root mean square.

E. SPDT: Single pole, double throw.

F. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS

A. Product Data: For each type of panelboard, overcurrent protective 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. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:

    a. Enclosure types and details for types other than NEMA 250, Type 1.
    b. Bus configuration, current, and voltage ratings.
    c. Short-circuit current rating of panelboards and overcurrent protective devices.
    d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 16 Section "Seismic Controls for Electrical Work." Include the following:

1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. The term "withstand" means "the unit will remain in place without separation of internal and external parts during a seismic event and the unit will be fully operational after the event."
3. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
4. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.

E. Field Test Reports: Submit written test reports and include 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.

F. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

G. Maintenance Data: For panelboards and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Contract Closeout," 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.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency 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 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 NEMA PB 1.

D. Comply with NFPA 70.

1.6 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, and encumbrances to workspace clearance requirements.

1.7 EXTRA MATERIALS

A. Keys: Six spares of each type of panelboard cabinet lock.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:

a. Square D Co.
b. General Electric Co.; Electrical Distribution & Control Div.

2.2 FABRICATION AND FEATURES

A. Enclosures: Surface-mounted cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.

B. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

C. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.

D. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.

E. Bus: Hard-drawn copper, 98 percent conductivity.

F. Main and Neutral Lugs: Mechanical type suitable for use with conductor material.

G. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.

H. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.

2.3 PANELBOARD SHORT-CIRCUIT RATING

A. Fully rated to interrupt symmetrical short-circuit current available at terminals.

B. Series rated panelboards are not acceptable.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Branch and Main Overcurrent Protective Devices: Bolt-on thermal magnetic circuit breakers, replaceable without disturbing adjacent units.

B. Circuit breakers on primary or secondary of dry type transformer refer to paragraph 2.6 for additional requirements.

C. Doors: Front mounted with concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.5 DISTRIBUTION PANELBOARDS

A. Doors: Front mounted; secured with vault-type latch with tumbler lock; keyed alike.

B. Main Overcurrent Protective Devices (if indicated): Electronic trip unit circuit breaker.

C. Branch overcurrent protective devices shall be as follows:

1. Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.6 OVERCURRENT PROTECTIVE DEVICES

A. 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.
2. Transformer Primary and Secondary Circuit Breakers: Square D models FA, FC, KC, LA, or General Electric models TEHD, THEF, THQD, THFK, THJK, circuit breakers with equivalent time-current curves as approved; or electronic trip unit breakers.
3. Adjustable Instantaneous-Trip Circuit Breakers: For circuit breaker frame sizes 200 A up to 400 A, magnetic trip element with front-mounted, field-adjustable trip setting.
4. Electronic Trip Unit Circuit Breakers: For circuit breaker frame sizes 400 A and larger, 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.

5. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity standard.

B. Molded-Case Circuit-Breaker Features and Accessories. Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment, and Type HID for metal halide and high pressure sodium lighting loads.
3. 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.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: To test functions of solid-state trip devices without removal from panelboard.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Comply with mounting and anchoring requirements specified in Division 16 Section "Seismic Controls for Electrical Work."

C. Mounting Heights: Top of trim 74 inches (1880 mm) above finished floor, unless otherwise indicated.

D. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

E. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Where electrical modifications are performed on existing panelboards, circuit directory shall be revised to reflect modified condition Circuit directory shall indicate room number and load type served by each circuit. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

F. Install filler plates in unused spaces.

G. Wiring in Panelboard Gutters: Arrange conductors into groups and bundle and wrap with wire ties after completing load balancing.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification."

B. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.3 CONNECTIONS

A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.

B. Install bonding jumper between ground busses of different panelboards serving patient care areas.

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.4 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Testing Agency: Engage a qualified independent testing agency to perform specified testing.

C. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. 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.

D. Balancing Loads: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes as follows:

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.

E. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 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 panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.6 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16442

SECTION 16443 - MOTOR-CONTROL CENTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes motor-control centers for use on ac circuits rated 600 V and less.

1.3 SUBMITTALS

A. Product Data: For each type of controller and each type of motor-control center. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each motor-control center.

1. 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 ratings of buses and installed units.
d. Vertical and horizontal bus capacities.
e. Features, characteristics, ratings, and factory settings of each motor-control center unit.

2. Wiring Diagrams: Power, signal, and control wiring for class and type of motor-control center. Differentiate between manufacturer-installed and field-installed wiring. Provide schematic wiring diagram for each type of controller.

C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around motor-control centers where pipe and ducts are prohibited. Show motor-control center 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 motor-control centers, accessories, and components will withstand seismic forces defined in Division 16 Section "Seismic Controls for Electrical Work." 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 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.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

F. Field Test Reports: Written reports specified in Part 3.

G. Manufacturer's field service report.

H. Maintenance Data: For motor-control centers, all installed devices, and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Closeout Procedures," include the following:

1. Routine maintenance requirements for motor-control centers and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

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.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent testing agency with the experience and capability to satisfactorily conduct the testing indicated, as documented according to ASTM E 548.

B. Source Limitations: Obtain controllers of a single type through one source from a single manufacturer.

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.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver motor-control centers in shipping splits of lengths that can be moved past obstructions in delivery path.

B. Handle motor-control centers according to NEMA ICS 2.3, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers." Use factory-installed lifting provisions.

C. Store motor-control centers indoors in clean, dry space with uniform temperature to prevent condensation. Protect motor-control centers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

D. If stored in areas subjected to weather, cover motor-control centers to protect 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

1.7 COORDINATION

A. Coordinate layout and installation of motor-control centers 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 3 Section "Cast-in-Place Concrete."

C. Coordinate features of motor-control centers, installed units, and accessory devices with pilot devices and control circuits to which they connect.

D. Coordinate features, accessories, and functions of each motor-control center, each controller, and each installed unit 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 not less 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: Subject to compliance with requirements, provide products by one of the following:

1. Motor-Control Centers with Manual and Magnetic Controllers:

a. Square D Co.
b. General Electrical Distribution & Control.

2.2 MOTOR-CONTROL CENTERS

A. Wiring: NEMA ICS 3, Class I, Type A.

B. Enclosures: Surface-mounted cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.

1. Compartments: Modular; individual doors with concealed hinges and quick-captive screw fasteners. Interlocks on combination controller units requiring disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.
2. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in motor-control center. Interchangeability of units requiring the same size compartment and constructed to permit ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.
3. Wiring Spaces: Wiring channel in each vertical section for vertical and horizontal wiring to each unit compartment; supports to hold wiring in place.

C. Short-Circuit Current Rating for Each Section: Equal to or greater than indicated available fault current in symmetrical amperes at motor-control center location.

2.3 BUSES

A. Material: Plated copper.

B. Ampacity Ratings: As indicated for horizontal and vertical main buses.

C. Neutral Buses: Full size.

D. Equipment Ground Bus: Noninsulated, horizontal copper bus 2 by 1/4 inch (50 by 6 mm), minimum.

E. Horizontal Bus Arrangement: Main phase, neutral and ground buses extended with same capacity the entire length of motor-control center, with provision for future extension at both ends by bolt holes and captive bus splice sections or equivalent.

F. Short-Circuit Withstand Rating: Same as short-circuit current rating of section.

2.4 FUNCTIONAL FEATURES

A. Description: Modular arrangement of controllers, control devices, overcurrent protective devices, instruments, blank panels, and other items mounted in compartments of motor-control center.

B. Controller Units: Combination controller units of types and with features, ratings, and circuit assignments indicated.

1. Install units with controllers (type as indicated on drawings) on drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
2. Provide units with short-circuit current ratings equal to or greater than short-circuit current rating of motor-control center section.

C. Overcurrent Protective Devices: Individual feeder-tap units through 225-A rating shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.

D. Transient Voltage Surge Suppressors: Connect to motor-control center bus.

E. Spaces and Blank Units: Compartments fully bused and equipped with guide rails or equivalent, ready for insertion of drawout units.

2.5 MAGNETIC MOTOR CONTROLLERS

A. Description: NEMA ICS 2, Class A, full voltage, nonreversing, across the line unless otherwise indicated.

B. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

C. Combination Controller: Factory-assembled combination controller and disconnect switch.

1. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

D. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class 10 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.

E. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition.

2.6 FEEDER OVERCURRENT PROTECTION

A. 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.
2. Transformer Primary and Secondary Circuit Breakers: Square D models FA, FC, KC, LA, or General Electric models TEHD, THEF, THQD, THFK, THJK, circuit breakers with equivalent time-current curves as approved; or electronic trip unit breakers.
3. Adjustable Instantaneous-Trip Circuit Breakers: For circuit breaker frame sizes 200 A and larger, magnetic trip element with front-mounted, field-adjustable trip setting.
4. Electronic Trip Unit Circuit Breakers: For circuit breaker frame sizes 400 A and larger, 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.

5. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity standard. Provide 30-mA trip sensitivity when used for equipment ground fault circuit interruption.

B. Molded-Case, Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
3. 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.

2.7 MOTOR-CONTROL CENTER 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. Multifunction Digital-Metering Monitor: UL-listed or -recognized, 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.

3. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.8 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested controllers before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive motor-control centers for compliance with requirements, installation tolerances, and other conditions affecting performance.

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

3.2 APPLICATIONS

A. Select features of each controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, 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. See Division 16 Section "Basic Electrical Materials and Methods" for general installation instructions.

B. Anchor each motor-control center assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with motor-control center mounting surface.

C. Install motor-control centers on concrete bases complying with Division 3 Section "Cast-in-Place Concrete."

D. Comply with mounting and anchoring requirements specified in Division 16 Section "Seismic Controls for Electrical Work."

3.4 IDENTIFICATION

A. Identify motor-control center, motor-control center components, and control wiring according to Division 16 Section "Electrical Identification."

B. Operating Instructions: Frame printed operating instructions for motor-control centers, including control sequences and emergency procedures. Fabricate frame of finished

metal and cover instructions with clear acrylic plastic. Mount on front of motor-control centers.

3.5 CONTROL WIRING INSTALLATION

A. Install wiring between motor-control devices according to Division 16 Section "Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where available.

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 motor-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.

3.6 CONNECTIONS

A. Conduit installation requirements are specified in other Division 16 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment.

C. 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.

3.7 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each motor-control center element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Testing: Engage a qualified testing agency to perform the following field quality-control testing:

1. Perform each electrical test and visual and mechanical inspection indicated in NETA ATS, Sections 7.5, 7.6, and 7.16.
2. 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.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including pretesting and adjusting reduced-voltage controlelrs.

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.

3.8 ADJUSTING

A. Set field-adjustable circuit-breaker trip ranges.

3.9 CLEANING

A. Clean controllers internally, on completion of installation, according to manufacturer's written instructions. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.10 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Verify that motor-control centers and components are installed and connected according to the Contract Documents.

C. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 16 Sections.

D. Complete installation and startup checks according to manufacturer's written instructions.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain motor-control centers.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules. Provide at least 8 hours of training.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."

3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 16443

SECTION 16461 - DRY-TYPE TRANSFORMERS (1000 V AND LESS)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 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. Control and signal transformers.

1.3 SUBMITTALS

A. Product Data: Include data on features, components, ratings, and performance for each type of transformer specified. Include dimensioned plans, sections, and elevation views. Show minimum clearances and installed devices and features.

B. Wiring Diagrams: Detail wiring and identify terminals for tap changing and connecting field-installed wiring.

C. Product Certificates: Signed by manufacturers of transformers certifying that the products furnished comply with requirements.

D. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

E. Factory Test Reports: Certified copies of manufacturer's design and routine factory tests required by referenced standards.

F. Sound-Level Test Reports: Certified copies of manufacturer's sound-level tests applicable to equipment for this Project.

G. Field Test Reports: Indicate and interpret test results for tests specified in Part 3.

H. Maintenance Data: For transformers to include in the maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: In addition to requirements specified in Division 1 Section "Quality Control," an independent testing agency shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907; or shall be a full-member company of the InterNational Electrical Testing Association.

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. Listing and Labeling: Provide transformers specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.

C. Comply with IEEE C2.

D. Comply with NFPA 70.

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 is not in a space that is continuously under normal control of temperature and humidity.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide transformers by one the following:

1. Square D; Groupe Schneider.
2. GE Electrical Distribution & Control.

2.2 TRANSFORMERS, GENERAL

A. Description: Factory-assembled and -tested, air-cooled units of types specified, designed for 60-Hz service.

B. Cores: Grain-oriented, nonaging silicon steel.

C. Coils: Copper. Continuous windings without splices, except for taps.

D. Internal Coil Connections: Brazed or pressure type.

E. Enclosure: Class complies with NEMA 250 for the environment in which installed.

F. Low-Sound-Level Units: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.3 GENERAL-PURPOSE DISTRIBUTION AND POWER TRANSFORMERS

A. Comply with NEMA ST 20 and list and label as complying with UL 1561.

B. Cores: One leg per phase.

C. Windings: One coil per phase in primary and secondary.

D. Enclosure: Indoor, ventilated, dripproof.

E. Insulation Class: 185 or 220 deg C class for transformers 15 kVA or smaller; 220 deg C class for transformers larger than 15 kVA.

1. Rated Temperature Rise: 115 deg C maximum rise above 40 deg C.

F. Taps: For transformers 3 kVA and larger, full-capacity taps in high-voltage windings are as follows:

1. Taps, 15 through 500 kVA: Six 2.5-percent taps, 2 above and 4 below rated high voltage.

G. Wall-Mounting Brackets: Manufacturer's standard brackets for transformers up to 75 kVA.

2.4 CONTROL AND SIGNAL TRANSFORMERS

A. Units comply with NEMA ST 1 and are listed and labeled as complying with UL 506.

B. Ratings: Continuous duty. If rating is not indicated, provide capacity exceeding peak load by 50 percent minimum.

C. Description: Self-cooled, 2 windings.

2.5 FINISHES

A. Indoor Units: Manufacturer's standard paint over corrosion-resistant pretreatment and primer.

2.6 SOURCE QUALITY CONTROL

A. Factory Tests: Design and routine tests comply with referenced standards.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with safety requirements of IEEE C2.

B. Arrange equipment to provide adequate spacing for access and for circulation of cooling air.

C. Identify transformers and install warning signs according to Division 16 Section "Electrical Identification."

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.2 GROUNDING

A. Separately Derived Systems: Comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near the transformer.

B. Comply with Division 16 Section "Grounding" for materials and installation requirements.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to supervise the field assembly and connection of components, and the testing and adjusting of transformer components and accessories.

B. Testing Agency: Engage a qualified independent testing agency to perform field quality-control testing.

C. Test Objectives: To ensure transformer is operational within industry and manufacturer's tolerances, is installed according to the Contract Documents, and is suitable for energizing.

D. Test Labeling: On satisfactory completion of tests for each transformer, attach a dated and signed "Satisfactory Test" label to tested component.

E. Schedule tests and provide notification at least 7 days in advance of test commencement.

F. Report: Submit a written report of observations and tests. Report defective materials and installation.

G. Tests: Include the following minimum inspections and tests according to manufacturer's written instructions. Comply with IEEE C57.12.91 for test methods and data correction factors.

1. Inspect accessible components for cleanliness, mechanical and electrical integrity, and damage or deterioration. Verify that temporary shipping bracing has been removed. Include internal inspection through access panels and covers.
2. Inspect bolted electrical connections for tightness according to manufacturer's published torque values or, if not available, those specified in UL 486A and UL 486B.
3. Insulation Resistance: Perform megohmmeter tests of primary and secondary winding to winding and winding to ground.

    a. Minimum Test Voltage: 1000 V, dc.
    b. Minimum Insulation Resistance: 500 megohms.
    c. Duration of Each Test: 10 minutes.
    d. Temperature Correction: Correct results for test temperature deviation from 20 deg C standard.

H. Test Failures: Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest. Verify that transformers meet specified requirements.

3.4 CLEANING

A. On completion of installation, inspect components. Remove paint splatters and other spots, dirt, and debris. Repair scratches and mars on finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

3.5 ADJUSTING

A. After installing and cleaning, touch up scratches and mars on finish to match original finish.

B. Adjust transformer taps to provide optimum voltage conditions at utilization equipment throughout normal operating cycle of facility. Record primary and secondary voltages and tap settings and submit with test results.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in readjusting transformer tap settings to suit actual occupied conditions. Provide up to 2 visits to Project site for this purpose without additional cost.

1. Voltage Recordings: Contractor performed. Provide up to 48 hours of recording on the low-voltage system of each medium-voltage transformer.
2. Point of Measurement: Make voltage recordings at load outlets selected by Owner.

END OF SECTION 16461

SECTION 16491 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes cartridge fuses, rated 600 V and less, for use in switches, panelboards, switchboards, controllers, and motor-control centers; and spare fuse cabinets.

1.3 SUBMITTALS

A. Product Data: Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings for each fuse type indicated.

B. Product Data: Include the following for each fuse type indicated:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
2. Let-through current curves for fuses with current-limiting characteristics.
3. Time-current curves, coordination charts and tables, and related data.
4. Fuse size for elevator feeders and elevator disconnect switches.

C. Ambient Temperature Adjustment Information. If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses adjusted.

1. For each adjusted fuse, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
2. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

D. Maintenance Data: For tripping devices to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Source Limitations: Provide fuses 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. Comply with NEMA FU 1.

D. Comply with NFPA 70.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (4.4 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.6 COORDINATION

A. Coordinate fuse ratings with HVAC and refrigeration equipment nameplate limitations of maximum fuse size.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged in original cartons or containers and identified with labels describing contents.

1. Fuses: Quantity equal to 10 percent of each fuse type and size, but not fewer than 3 of each type and size.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Industries, Inc.; Bussmann Div.
2. Gould Shawmut.
3. Tracor, Inc.; Littelfuse, Inc. Subsidiary.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

2.3 SPARE FUSE CABINET

A. Cabinet: Wall-mounted, 0.05-inch- (1.27-mm-) thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch- (40-mm-) high letters on exterior of door.
4. Fuse Pullers: For each size fuse.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.2 FUSE APPLICATIONS

A. Motor Branch Circuits: **Class RK5, time delay.**

B. Other Branch Circuits: **Class RK5, time delay.**

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare fuse cabinet[s].

3.4 IDENTIFICATION

A. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION 16491

SECTION 16511 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Interior lighting fixtures with lamps and ballasts.
2. Lighting fixtures mounted on exterior building surfaces.
3. Emergency lighting units.
4. Exit signs.

B. Related Sections include the following:

1. Division 16 Section "Wiring Devices" for manual wall-box dimmers for incandescent lamps.
2. Division 16 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

A. BF: Ballast factor. Ratio of light output of a given lamp(s) operated by the subject ballast to the light output of the same lamp(s) when operated on an ANSI reference circuit.

B. CRI: Color rendering index.

C. CU: Coefficient of utilization.

D. LER: Luminaire efficiency rating, which is calculated according to NEMA LE 5. This value can be estimated from photometric data using the following formula:

1. LER is equal to the product of total rated lamp lumens times BF times luminaire efficiency, divided by input watts.

E. RCR: Room cavity ratio.

1.4 SUBMITTALS

A. Product Data: For each type of lighting fixture scheduled, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of fixture, including dimensions and verification of indicated parameters.
2. Emergency lighting unit battery and charger.
3. Fluorescent and high-intensity-discharge ballasts.
4. Lamps.

B. Wiring Diagrams: Power, signal, and control wiring.

C. Shop Drawings: Show details of nonstandard or custom fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.

D. 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. Structural members to which lighting-fixture suspension systems will be attached.
2. Suspended ceiling components.
3. Other items in finished ceiling, including the following:

a. Mechanical ductwork.
b. Mechanical piping.
c. Fire protection piping.
d. Access panels.

E. Source quality-control test reports.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Catalog data for each fixture. Include the diffuser, ballast, and lamps installed in that fixture.

H. Warranties: Special warranties specified in this Section.

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.

C. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

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 Emergency Lighting Unit Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.

B. Special Warranty for Fluorescent 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.

C. Manufacturer's Special Warranty for 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: One year 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 two of each type.
2. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least two 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 two of each type.
5. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least two of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Refer to Lighting Fixture Schedule on drawings.

2.2 FIXTURES AND COMPONENTS, GENERAL

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

C. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.

D. Metal Parts: Free of burrs and sharp corners and edges.

E. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

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.

G. 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.

H. 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 (3.175 mm) minimum unless different thickness is scheduled.
b. UV stabilized.
c. Prismatic troffers shall have acrylic, pattern #12 lenses.
d. Parabolic troffers shall have semi-diffuse lover in 3x6 cell configuration for a 2'x4' fixture.

I. Electromagnetic-Interference Filters: A component of fixture assembly. Suppress conducted electromagnetic-interference as required by MIL-STD-461D. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.

2.3 FLUORESCENT LAMP BALLASTS

A. Description: Include the following features, unless otherwise indicated:

1. Designed for type and quantity of lamps indicated at full light output.

B. Electronic ballasts for linear lamps shall include the following features, unless otherwise indicated:

1. Comply with NEMA C82.11.
2. Ballast Type: Instant start, unless otherwise indicated.
3. Programmed Start: Ballasts with two-step lamp starting to extend life of frequently started lamps.
4. Sound Rating: A.
5. Total harmonic distortion rating of less than 10 percent according to NEMA C82.11.
6. Transient Voltage Protection: IEEE C62.41, Category A.
7. Operating Frequency: 20 kHz or higher.
8. Lamp Current Crest Factor: Less than 1.7.
9. Parallel Lamp Circuits: Multiple lamp ballasts connected to maintain full light output on surviving lamps if one or more lamps fail.

C. Electromagnetic ballasts for linear lamps shall have the following features, unless otherwise indicated:

1. Comply with NEMA C82.1.
2. Type: Energy-saving, high power factor, Class P, automatic-reset thermal protection.
3. Ballast Manufacturer Certification: Indicated by label.
4. Provide lamp end-of-life detection and shutdown circuit for T5 diameter lamps.

D. Ballasts for compact lamps in recessed fixtures shall have the following features, unless otherwise indicated:

1. Type: Electronic.
2. Power Factor: 90 percent, minimum.

3. Flicker: Less than 5 percent.
4. Lamp Current Crest Factor: Less than 1.7.
5. Electronic Ballast Operating Frequency: **20 kHz** or higher.
6. Lamp end-of-life detection and shutdown circuit.
7. Transient Protection: Comply with IEEE C62.41 for Category A1 locations.
8. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

E. Ballasts for compact lamps in nonrecessed fixtures shall include the following features, unless otherwise indicated:

1. Power Factor: 90 percent, minimum.
2. Ballast Coil Temperature: 65 deg C, maximum.
3. Transient Protection: Comply with IEEE C62.41 for Category A1 locations.
4. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

F. Ballasts for dimmer-controlled fixtures shall comply with general and fixture-related requirements above for electronic ballasts and the following features:

1. Dimming Range: 100 to 1 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 system indicated.

G. Ballasts for Low-Temperature Environments:

1. Temperatures 0 deg F (Minus 17 deg C) and Higher: Electronic type rated for 0 deg F minus 17 deg C starting temperature.

H. 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.

2.4 HIGH-INTENSITY-DISCHARGE LAMP BALLASTS

A. General: Comply with NEMA C82.4 and UL 1029. Shall include the following features, unless otherwise indicated.

1. Type: Constant-wattage autotransformer or regulating high-power-factor type.
2. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C) for single-lamp ballasts.
3. Normal Ambient Operating Temperature: 104 deg F (40 deg C).
4. Open-circuit operation that will not reduce average life.

B. Auxiliary, Instant-On, Quartz System: Automatically switches quartz lamp on when fixture is initially energized and when momentary power outages occur. Automatically turns quartz lamp off when high-intensity-discharge lamp reaches approximately 60 percent light output.

C. Low-Noise Ballasts: Manufacturers' standard epoxy-encapsulated models designed to minimize audible fixture noise.

2.5 EXIT SIGNS

A. General: Comply with UL 924; for sign colors and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: Light-emitting diodes, 70,000 hours minimum of rated lamp life.

2.6 EMERGENCY LIGHTING UNITS

A. General: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type with minimum 10-year nominal life and special warranty.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.

2.7 FLUORESCENT LAMPS

A. Low-Mercury Lamps: Comply with Federal toxic characteristic leaching procedure test, and 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, 2800 initial lumens (minimum), CRI of 83 (minimum), color temperature of 3500 K, and average rated life of 20,000 hours, unless otherwise indicated.

C. Compact Fluorescent Lamps: CRI 80 (minimum), color temperature 3500K, average rated life of 10,000 hours at 3 hours operation per start, unless otherwise indicated.

1. Compact fluorescent lamps used in dimming applications shall be operated for at least 100 hours at full intensity prior to application of dimming functions.

2.8 HIGH-INTENSITY-DISCHARGE LAMPS

A. Metal-Halide Lamps: ANSI C78.1372, wattage and burning position as scheduled, CRI 65 (minimum), and color temperature 4000.

2.9 FIXTURE SUPPORT COMPONENTS

A. Comply with Division 16 Section "Basic Electrical Materials and Methods" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) 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, 12 gage (2.68 mm).

E. Rod Hangers: 3/16-inch- (5-mm-) minimum diameter, cadmium-plated, threaded steel rod.

F. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

G. Aircraft Cable Support: Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.

2.10 FINISHES

A. Fixtures: Manufacturers' standard, unless otherwise indicated.

1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.
2. Metallic Finish: Corrosion resistant.

2.11 SOURCE QUALITY CONTROL

A. Provide services of a qualified, independent testing and inspecting agency to factory test fixtures with ballasts and lamps; certify results for electrical ratings and photometric data.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Support for Fixtures in or on Grid-Type Suspended Ceilings: Fixtures shall not be independently supported from ceiling grid. Fixture supports system shall include support from structural ceiling for all fixtures.

1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches (150 mm) from fixture corners.
2. Support Clips: Fasten to 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 (20-mm) metal channels spanning and secured to ceiling tees.

C. Suspended Fixture Support: As follows:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Suspend from cable.

D. Adjust aimable fixtures to provide required light intensities.

3.2 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.3 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Verify normal operation of each fixture after installation.

C. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify normal transfer to battery power source and retransfer to normal.

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.

E. Corroded Fixtures: During warranty period, replace fixtures that show any signs of corrosion.

END OF SECTION 16511

SECTION 16521 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Exterior luminaires with lamps and ballasts not listed in other specification sections.
2. Luminaire-mounted photoelectric switches.

1.3 SUBMITTALS

A. Product Data: For each luminaire, arranged in the order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1. Physical description of fixture, including dimensions and verification of indicated parameters.
2. Luminaire dimensions, effective projected area, details of attaching luminaires, accessories, and installation and construction details.
3. Luminaire materials.
4. Photoelectric relays.
5. High-intensity-discharge ballasts.
6. High-intensity-discharge lamps.
7. Electrical and energy-efficiency data for ballasts.

B. Wiring Diagrams: Power, signal, and control wiring.

C. Shop Drawings: Anchor-bolt templates keyed to specific poles and certified by manufactuer.

D. Coordination Drawings: Mounting and connection details, drawn to scale, for exterior luminaires with requirements specified in Division 2 Section "Lighting Poles and Standards."

E. Source quality-control test reports.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For luminaires to include in maintenance manuals.

H. Warranties: Special warranties specified in this Section.

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.

B. Comply with IEEE C2, "National Electrical Safety Code."

C. Comply with NFPA 70.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace luminaires or components of luminaires and lamps that fail in materials or workmanship; corrode; or fade, stain, 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: Five years from date of Substantial Completion.

    a. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
    b. Warranty Period for Color Retention: Five years from date of Substantial Completion.

2. Warranty Period for Lamps: Replace lamps and fuses that fail within 12 months from date of Substantial Completion; furnish replacement lamps and fuses that fail within the second 12 months from date of Substantial Completion.

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. Lamps: 10 for every 100 of each type and rating installed. Furnish at least two 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 two of each type.
3. Ballasts: 10 for every 100 of each type and rating installed. Furnish at least two of each type.

4. Globes and Guards: 10 for every 20 of each type and rating installed. Furnish at least two of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Refer to Lighting Fixture Schedule on drawings.

2.2 LUMINAIRES, GENERAL

A. Complying with UL 1598 and listed for installation in wet locations.

B. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.

D. Metal Parts: Free of burrs and sharp corners and edges.

E. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

F. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

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. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

H. Exposed Hardware Material: Stainless steel.

I. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

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. HID fixtures shall be fused.

2.3 PHOTOELECTRIC RELAYS

A. UL 773 or UL 773A listed, factory mounted to the luminaire.

B. Contact Relays: Single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay.

1. Relay with locking-type receptacle shall comply with NEMA C136.10.
2. Adjustable window slide for adjusting on-off set points.

2.4 HIGH-INTENSITY-DISCHARGE LAMP BALLASTS

A. General: Comply with NEMA C82.4 and UL 1029. Shall include the following features, unless otherwise indicated:

1. Type: Constant-wattage autotransformer or regulating high-power-factor type.
2. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C) for single-lamp ballasts.
3. Normal Ambient Operating Temperature: 104 deg F (40 deg C).
4. Open-circuit operation will not reduce average life.
5. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.

B. Auxiliary, Instant-On, Quartz System: Automatically switches quartz lamp on when fixture is initially energized and when momentary power outages occur. Automatically turns quartz lamp off when high-intensity-discharge lamp reaches approximately 60 percent light output.

C. High-Pressure-Sodium Ballasts: Solid-state igniter/starter with an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.

1. Instant Restrike Device: Solid-state potted module, mounted inside high-pressure-sodium fixture and compatible with high-pressure-sodium lamps, ballasts, and 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. Single-Lamp Ballasts: Minimum starting temperature of minus 40 deg C.
3. Open-circuit operation will not reduce average life.

2.5 HIGH-INTENSITY-DISCHARGE LAMPS

A. High-Pressure-Sodium Lamps: NEMA C78.42, wattage and burning position as scheduled, CRI 21 (minimum), color temperature 1900, and average rated life of 24,000 hours.

B. Metal-Halide Lamps: ANSI C78.1372, wattage and burning position as scheduled, CRI 65 (minimum), and color temperature 4000.

2.6 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match process and color of support materials.

2.7 SOURCE QUALITY CONTROL

A. Provide services of a qualified, independent testing and inspecting agency to factory test luminaires with lamps; certify results for isofootcandle curves, zonal lumen, average and minimum ratios.

B. Factory test fixtures with lamps; certify results for isofootcandle curves, zonal lumen, average and minimum ratios.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lamps in each fixture.

B. Luminaire Attachment: Fasten to indicated structural supports.

C. Adjust luminaires that require field adjustment or aiming.

3.2 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.

3.3 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Tests and Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):

1. IESNA LM-5.
2. IESNA LM-50.
3. IESNA LM-52.
4. IESNA LM-64.
5. IESNA LM-72.

C. 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 16521

SECTION 16570 - DIMMING CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Manual, modular dimming controls.
2. Integrated, multipreset, modular dimming controls.
3. Multichannel, remote-controlled dimmers.
4. Remote-controlled dimming stations.

B. Related Sections include the following:

1. Division 16 Section "Wiring Devices" for wall-box dimmers and manual light switches.
2. Division 16 Section "Lighting Control Devices" for time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 SUBMITTALS

A. Product Data: Include dimensions and data on features, components, and ratings for dimming controls. Include elevation views of front panels of control and indicating devices and control stations. Also include the following:

1. List of ballasts and lamp combinations compatible with dimmer controls, by manufacturer and catalog number.
2. Sound data, including results of operational tests of dimming controls.
3. Operational documentation for software and firmware.

B. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.

1. Wiring Diagrams: Detail specific systems tailored to this Project and differentiate between manufacturer-installed and field-installed wiring.

C. Samples: Flush-mounted, dimming control station faceplates for color selection and evaluation of technical features.

D. Manufacturer Certificates: Signed by manufacturers certifying that they comply with requirements.

E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

F. Maintenance Data: For dimming controls to include in maintenance manuals specified in Division 1. Include software operating manuals.

G. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain dimming controls from a single source with total responsibility for compatibility of lighting control system components specified in this Section, in Division 13 Section "Lighting Controls," and in Division 16 Section "Lighting Control Devices."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for their indicated use and installation conditions by a testing agency acceptable to authorities having jurisdiction.

C. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.

D. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate features of devices specified in this Section with systems and components specified in other Sections to form an integrated system of compatible components. Match components and interconnections for optimum performance of specified functions. Include coordination with the following:

1. Division 16 Section "Lighting Control Devices."

1.6 WARRANTY

A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of dimming controls that fail in materials or workmanship within specified warranty period.

C. Warranty Period: Two years from date of Substantial Completion.

1.7 EXTRA MATERIALS

A. Furnish extra products described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra products to Owner.

1. Dimmer Modules: 1 for every 10 of each type and rating 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 the following:

1. Crestron Electronics, Inc.
2. Diversified Electronics, Inc.
3. Lightolier.
4. Lithonia Control Systems.
5. Lutron Electronics Co., Inc.
6. Sterner Lighting Systems, Inc.
7. Strand Lighting.

2.2 GENERAL DIMMING DEVICE REQUIREMENTS

A. Line-Voltage Surge Protection: Include in all 120- and 277-V solid-state equipment. Comply with UL 1449 and with ANSI C62.41 for Category A locations.

B. Compatibility: Dimming control components shall be compatible with other elements of interconnected lighting controls and with connected loads as to communication, signaling, and control functions.

C. Dimmers and Dimmer Modules: Comply with UL 508.

1. Audible Noise and Radio-Frequency Interference Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dim-

mer noise or radio-frequency interference at any setting. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.

2. Dimmer or Dimmer-Module Rating: As indicated, but not less than 125 percent of connected load.

D. Panic Switch: Include where indicated or required by authorities having jurisdiction. Switch operation overrides dimmer settings and restores lights on connected output circuits to full brightness regardless of settings.

2.3 INTEGRATED, MULTIPRESET, MODULAR DIMMING CONTROLS

A. Description: Microprocessor-based, solid-state controls.

1. Operation: Automatically changes variable dimmer settings of different groups of lights (channels) simultaneously from one preset scene to another when a push button is operated.
2. Each system includes a control panel and one to four dimmer-control modules. Panels and modules are integrally flush mounted in a single wall box.

B. Control panel adjusts each dimmer channel setting for each scene and commands change from one preset scene to another. Control positions or displays at control panel indicate dimmer settings for each channel for each scene.

C. Timed cross-fade action occurs when one preset scene is switched to another.

2.4 LOW-VOLTAGE WIRING

A. Digital and Multiplexed Signal Wire: Shielded, twisted-pair cable as specified in Division 16 Section "Voice and Data Systems."

B. 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 Switch Circuits: Three conductors, unless otherwise indicated.
3. Switch Circuits with Pilot Lights or Locator Feature: Five conductors, unless otherwise indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment level and plumb and according to manufacturer's written instructions.

B. Mount control equipment according to manufacturer's written instructions and requirements in Division 16 Section "Basic Electrical Materials and Methods."

C. Mounting heights indicated are to bottom of unit for suspended items and to center of unit for wall-mounting items.

3.2 CONTROL WIRING INSTALLATION

A. Install wiring as specified in Division 16 Section "Conductors and Cables" for low-voltage connections.

B. Wiring Method: Install all wiring in raceway as specified in Division 16 Section "Raceways and Boxes."

C. Bundle, train, and support wiring in enclosures.

D. Ground equipment.

E. Connections: 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.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Division 16 Section "Electrical Identification."

B. Label each system control module and each remote dimmer bank with a unique designation. Make designations on elevated components readable from floor.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Engage a factory-authorized service representative to test, adjust, and program dimming controls.

B. Schedule visual and mechanical inspections and electrical tests with at least seven days' advance notice.

C. Inspect control components for defects and physical damage, testing laboratory labeling, and nameplate compliance with the Contract Documents.

D. Check tightness of electrical connections with torque wrench calibrated within previous six months. Use manufacturer's recommended torque values.

E. Verify settings of photoelectric devices with photometer calibrated within previous six months.

F. Electrical Tests: Use particular caution when testing devices containing solid-state components. Perform the following according to manufacturer's written instructions:

1. Continuity tests of circuits.
2. Operational Tests: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.

    a. Include testing of dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

G. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

H. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

I. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.5 CLEANING

A. Cleaning: Clean equipment and devices internally and externally using methods and materials recommended by manufacturers, and repair damaged finishes.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

1. Train Owner's maintenance personnel on troubleshooting, servicing, adjusting, and maintaining equipment and schedules. Provide a minimum of two four-hour sessions on separate days for training. Use both classroom training and hands-on exercises.
2. Training Aid: Use the approved final version of maintenance manuals as a training aid.
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.7 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested, to adjust light levels, make preset scene changes, and adjust controls to suit actual conditions.

END OF SECTION 16570

SECTION 16630 - ISOLATED POWER SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section includes isolated power systems and associated auxiliary equipment which include the following:

1. Surgical facility isolated power panels.

1.2 RELATED WORK

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Requirements of the following Division 16 Sections apply to this Section:

1.3 SUBMITTALS

A. Submit pertinent descriptive catalog literature, specifications, and wiring diagrams. Include dimensional data and complete raceway and wiring diagrams for each assembly device.

B. Shop drawings shall include the following:

1. Overcurrent protection device schedule.
2. Dimensional data.
3. Transformer data.
4. L.I.M. details and data.
5. Manufacturer's current product specifications.

C. Submit isolated power systems test reports.

D. Submit evidence of UL labeling on Shop Drawings.

E. Submit leakage current of isolation transformer.

1.4 QUALITY ASSURANCE

A. Reference Standards:

1. Underwriters Laboratories Standard UL 1047 - Isolated Power System Distribution Equipment
2. Underwriters Laboratories Standard UL 1022 - Line Isolation Monitor
3. Underwriters Laboratories Standard UL 50
4. NEC - Article 517
5. NFPA 99 - Health Care Facilities

B. Construction Standards:

1. Isolation Panel shall be UL listed and labeled as an assembly.

PART 2 - PRODUCTS

2.1 ISOLATED POWER PANELS

A. Enclosure

1. Backbox:

a. Shall be recessed mounted as indicated on the contract documents. Recessed units shall be fabricated from 14 GA galvanized sheet steel. Maximum dimension of the backbox shall be 24" wide, 41" high and 12" deep.

2. Backplate:

a. Shall be fabricated from 12 GA galvanized sheet steel. The backplate shall provide a mounting surface for the isolated power center components. The backplate shall be mounted to the backbox by means of four 1/4" - 20 x 1.5" welded studs.

3. Faceplate:

a. Shall be fabricated from 14 GA #304 Stainless Steel, #4 brushed finish. Faceplate shall contain a flush door covering the circuit breaker section. The door shall contain a flush lock, all panels shall be keyed alike. Faceplate shall contain a cut-out for the L.I.M., which shall remain visible at all times. Faceplate shall also contain a cut out for the receptacle and ground jack section. The faceplate for recessed units shall overlap the enclosure by a minimum of 1" on all sides. Faceplate for surface units shall exactly match the

dimensions of the backbox. The faceplate shall be attached to the backbox by means of 8 #10-32 x 1" stainless steel screws.

B. Components

1. Isolation Transformer:

a. Single phase, 60 Hz with primary and secondary voltages as indicated on the contract drawings.

b. Use class H rated insulation in manufacture of transformer.

c. Wind with electrostatic shield between primary and secondary windings, and ground to enclosure.

d. Design electrostatic shield so that it will prevent direct shorting of primary winding to secondary winding, and reduce coupling of harmonic distortions between primary circuit and secondary circuits.

e. Core: stacked design, securely clamped and bolted.

f. Core and coil shall be vacuum impregnated, with final wrap of insulating material.

g. Internally isolate core and coils from enclosure by means of suitable vibration dampening system.

h. Total leakage current to ground from transformer secondary winding shall be in compliance with UL-1047, tables 30.1 and 30.2

i. Maximum sound level of transformer: 25 dB.

j. Limit temperature rise to 55 degree C above ambient under full load conditions.

k. Transformer shall be U.L. listed, or recognized as a component, at the voltages, amperages, and KVA ratings required.

2. Line Isolation Monitor:

a. The L.I.M. shall be a solid state modular assembly which utilizes the dynamic principal of constantly monitoring both sides of the line to ground.

b. Monitoring shall be accomplished electronically, without mechanical devices, and shall provide visual and audible indication from a first fault condition.

c. The L.I.M. shall be capable of detecting all combinations of capacitive and resistive faults, including balanced, unbalanced, and hybrid.

d. The total hazard index shall be set at the factory to either 2 mA or 5 mA, and shall be field adjustable to either milliamp level by toggling a dip switch located within the modular L.I.M. assembly.

e. Provide a continuous reading meter (digital or analog). The meter shall be flush with the face of the L.I.M.

f. Provide an audible alarm which shall sound in the event of a hazardous condition.

g. Provide a set of indicating lights to visually indicate the status of the system. Green shall indicate "safe," red shall indicate "hazard," and amber to indicate that the audible alarm feature is in the "mute" mode. All test switches shall be flush with the face of the L.I.M.

h. Provide a test switch on the face of the L.I.M. so that the functions of the unit can be tested by hospital personnel. It shall not be possible to leave the test switch in the "test" position. The test switch shall be flush with the face of the L.I.M.

i. Provide terminals within the Isolated Power Panel for connection of a modular remote indicator of the L.I.M. functions.

3. Primary Circuit Breaker:

a. Sized in accordance with NFPA 70-1990(NEC), NFPA 99-1990, and UL-1047 standards, based on the primary voltage as shown on the contract documents.

b. Full size, thermal magnetic type, with AIC as shown on the contract drawings.

4. Secondary Branch Breakers:

a. 20 amp, 2 pole in accordance with NFPA 70-1990(NEC), NFPA 99-1990, and UL-1047 standards.

b. Full size, thermal magnetic type, 10,000 AIC.

c. Provide each panel with quantity as required per the contract documents.

5. Reference Grounding Bus:

a. Grounding bus shall contain a minimum of one (1) #1/0 and eighteen (18) #14 to #6 grounding lugs.

2.2 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:

1. Post Glover.
2. Square D

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Install backboxes and frame supports and/or mountings of size and type recommended by manufacturer's representative to suit assembly and location shown on Drawings.

B. Provide interconnecting wire and cable between components or modules as specified and recommended by the manufacturer's representative.

1. Install power conductors, in conduit, from the laser isolated power panel serving the area to the laser receptacle/hazard indicator modules installed in the rooms. Power conductor insulation shall be cross-link polyethylene, with a dielectric constant of 3.5 or less.

2. Install hazard indicator wiring, in conduit, from the hazard alarm indicator in the module to the terminal strip provided in the x-ray isolated power panel.

C. Make conduit runs direct to limit conductor length. Horizontal runs in walls and point-to-point runs in ceilings are permitted.

D. Pull wire without the use of lubricants.

E. Ground isolation transformer electrostatic shield to room equipotential ground bus.

F. Install ground conductor, in conduit, from the ground lug on each laser receptacle to the reference ground bus in the x-ray isolated power panel. Run each ground conductor directly back to the reference ground bus.

3.2 TESTING AND CERTIFICATION

A. Scope of Work:

1. Provide manufacturer's engineer or technician for final testing of Isolated Power Panels and the related system as follows:

   a. Simulate various combinations and types of faults at each receptacle to ascertain correct function of L.I.M.

   b. Check calibration of L.I.M. meter and record readings.

   c. Record and date all data in permanent log book.

   d. Certify that the system is properly installed and in correct working order.

   e. The factory representative shall turn over to the facility maintenance department a set of test equipment consisting of a ground integrity tester, current leakage tester, and plug-in L.I.M. tester.

3.3 STAFF INSTRUCTION

A. Scope of Work:

1. Perform demonstration of the Isolated Power Panels and Systems, and instruct staff as follows:

   a. Demonstrate the test functions of the L.I.M.

   b. Instruct facility maintenance and medical staff on correct operation and routine testing of the Isolated Power Panels and Systems.

   c. Instruct the facility maintenance staff on the proper use of the test equipment.

   d. Demonstrated the proper method of recording data gathered from the testing of the system in the log book.

   e. Furnish a log book with the factory technician's readings gathered during the initial testing of the system.

   f. Furnish three (3) sets of Operation and Maintenance manuals to the facility maintenance staff. These manuals shall include written instruction on the care and maintenance of the system, replacement part list, and certified "as built" drawings of the material furnished for this facility.

SECTION 16715 - PREMISES TELEPHONE WIRING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes premises wiring for telephone distribution, including installations for service by local telephone exchange carrier.

1.3 DEFINITIONS

A. Local Exchange Carrier: Telephone utility or other entity that provides an access line from a local exchange into the premises.

B. Exchange Access Line: Circuit carrying telephone service into the premises.

C. Distribution Circuit: Circuit from the network interface device to a distribution device, such as a terminal block or junction box.

D. Station Circuit: Circuit from a distribution device to a telecommunications outlet.

E. Telecommunications Outlet: Telephone jack for connecting equipment to communication circuits.

1.4 SUBMITTALS

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

B. Product Certificates: Signed by manufacturers of transmission media certifying that the products furnished comply with requirements and that they have been coordinated with and accepted by the manufacturer of connected equipment.

C. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Maintenance Data: To include in the maintenance manuals specified in Division 1.

F. The submittal shall contain reference to specified manufacturers' catalog numbers which shall be qualified in writing if required to meet the product performance or characteristics described in the Project's drawings or specifications.

G. All submittals shall contain a list of all equipment and materials to be supplied by the contractor for completion of the Project. Only materials and equipment referenced in the specifications shall be accepted. In the event that a new number since the preparation of the Project's drawings and specifications has superceded any specified manufacturer's part number, the new number shall be provided with the old catalog number noted as a reference on the submittal.

H. All equipment and material submittals shall have a letter included with the submittal that lists the delivery lead-time requirements for each item in the submittal. The delivery lead-time is the number of CALENDAR days between the time the order for an item is placed with the distributor and the time it can be delivered to the work site. No proposed item shall be reviewed without its delivery lead time indicated.

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.

B. All cabling shall be provided, installed, supported and fastened according to NFPA, state, local and the ANSI/EIA/TIA 568A Commercial Building Telecommunications Cabling Standards and the ANSI/EIA/TIA 569 specification.

C. Comply with EIA/TIA 570.

D. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging temporary utility services according to requirements indicated:

1. Notify Architect not less than 2 days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.
3. Coordinate all outages and service interruptions with the architect and the owner.

1.7 COORDINATION

A. Coordinate premises wiring with requirements of local telephone exchange carrier.

B. Coordinate premises wiring with requirements of Maine Medical Center Information Systems standards and telephone equipment supplier.

PART 2 - PRODUCTS

2.1 COMPONENTS

A. Comply with EIA/TIA 570.

B. Telecommunications and Auxiliary Disconnect Outlets: Four-position modular, latching, plug-type, jack-in, flush-mounting wall plate, unless otherwise indicated. Refer to contract documents for arrangement of jacks in outlets.

C. Outlets shall be mounted in standard 2 ½"x2"x4" backboxes.

D. Wall Plates: Designed for combined tel/data services. Match those indicated for power receptacle outlets in same spaces for materials and finish. For wall telephone units, include provision for support of unit. Refer to contract documents for arrangement of jacks in outlets.

E. Distribution and Station Cable: Four-pair, Category 3 UTP.

1. Comply with ICEA S-80-576.
2. Provide plenum rated cable for all applications.
3. Provide Berktek 4-pair Category 3 gray Plenum UTP cable.

F. Cabinets: Comply with Division 16 Section "Raceways and Boxes." Furnish cabinets with backboard.

G. Backboard: 3/4-inch (19-mm) A/C grade fire rated plywood. Height and width shall cover entire wall up to 96 inches (2500 mm) above floor, unless otherwise indicated. Refer to contract documents for additional information.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Telephone Service: Comply with local telephone exchange carrier's requirements for details of telephone service.

B. Install outlet boxes and telecommunications outlets.

C. Install cable without damaging conductors and jacket.

1. Do not bend cable to a smaller radius than minimum recommended by manufacturer.

D. Install premises wiring in raceways, unless otherwise indicated.

1. Install cables in walls unless walls are solid or filled with insulation. In solid walls, install in raceway and terminate raceway with a bushing in ceiling space above outlet.
2. Install cables without raceway where concealed in accessible ceiling space, unless otherwise indicated.
3. Use pulling methods that will not damage cable or raceway, including fish tape, cable, rope, and wire-cable grips. Do not exceed manufacturer's recommended pulling tensions.
4. Pull cables simultaneously where more than one is being installed in the same raceway or at the same location.
5. Conceal raceway, except in unfinished spaces and as indicated.

E. Install exposed cable parallel or perpendicular to surfaces or exposed structural members and follow surface contours where possible.

F. Secure cable to cable management system (CMS), at intervals as required to prevent sagging between supports.

G. Four inch sleeved penetrations shall be provided in all firewalls adjacent to CMS or as indicated on contract drawings.

H. The contractor shall perform all terminations at the origination and outlet end. The contractor shall supply all cable and termination equipment.

I. All cables shall be labeled with a unique ID for each cable with corresponding labels at the origination point (closet) and faceplate (station).

J. All cables shall be bundled neatly, tie wrapped, and dressed into the termination panels. Origination (closet) and termination (station) points shall be identified on the project prints.

K. Installation of cables shall be accomplished according to the contract drawings. One 4-pair Category 3 UTP cable and one 4-pair Category 5-E UTP cable (refer to specification 16121 for Category 5 UTP cable requirements) shall be installed at each location with a minimum of 10 feet of slack for a service loop both at the closet in a tray and at the station end in a secure coil.

L. All cable shall be placed along established cable pathways (CMS) without weaving between pipes, conduit, etc. All direction changes shall be at ninety (90) degree angular turns. Consult the BICSI Telecommunications Design Manual (TDM) for clarification of these requirements.

M. For all standard installations, the voice cable shall be terminated on the top two RJ25C jacks with the 4 pair cable split between the two jacks. The white/orange-white/blue pairs shall be terminated on jack "A" and the white/brown-white/green pairs terminated on jack "B". (The data cable shall be terminated normally on the left most RJ45 jack. The right jack is left blank except for video conferencing applications).

N. The cable shall be dressed and tie wrapped along the cable path.

O. All cabling (including multi pair) shall be identified by printed labels, the cable range, as documented in the contract documents. This must be done on both ends of the cable as well as at each side of any penetration point and numbers shall be retained on the cable sheath after termination. All 4 pair station cables shall be treated in the same manner using the defined station number indicated on the master plan.

P. All voice cables shall be terminated into approved Ortronics components at the station ends. NOTE: All Part Numbers are listed in Appendix A.

Q. All diagrams depicting rack layouts, patch panel locations, room layouts, and backboard plans shall be followed exactly as outlined. No deviations to these plans shall be acceptable without the written consent of MMC personnel. NOTE: All Part Numbers are listed in Appendix A.

R. All riser cabling shall be run in a separate conduit. Conduit shall be sized to allow free movement of the riser cable depending on pair counts and O.D. of cable. Riser cable shall be pulled and terminated according to EIA/TIA specifications and labeled as outlined in the contract documents with the corresponding cable number and origination point (from-to) at each end as well as all penetration points. NOTE: All Part Numbers are listed in Appendix A.

S. All Grounding installations shall be in accordance with all State and Federal regulations and shall follow any and all NEC, EIA/TIA, and BICSI Standards. Refer to contract drawings for additional information.

3.2 PAR X

A. All Par X connections shall be installed at the height of 18"from the ceiling unless otherwise noted on the contract drawings and shall follow the standard wall jack numbering scheme noted above. This cable installed shall be a standard Category 3 cable. All Par X locations are indicated on the contract drawings.

3.3 CONNECTIONS

A. Ground equipment.

1. Install ground terminal at local exchange carrier service location and connect according to Division 16 Section "Grounding."
2. Tighten electrical connectors and terminals according to manufacturers published torque-tightening values. If manufacturers torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 IDENTIFICATION

A. Identify components and circuits according to Division 16 Section "Electrical Identification" and this specification.

B. Identify telephone system backboards and cabinets with the legend "Telephone."

C. Identify terminals at terminal strips, telecommunications outlets, and pull-and-junction boxes with approved designations.

3.5 FIELD QUALITY CONTROL

A. Testing: Engage a qualified testing agency to perform the following field quality-control testing:

1. All pairs must be tested for continuity and polarity.

2. Any pairs that do not pass shall be reterminated and retested. If unable to repair any pair within a riser system they must be clearly marked as a bad pair by blacking out the color code on the 110 or BIX block and listing on the designation strip as B/P. Hard copy documentation shall be provided to the Cable Management Technician to make MMC aware that the pairs are not in a usable condition. MMC will not be held responsible for costs associated with bad pairs.

3. All voice testing equipment used shall be able to determine short circuits, opens, reverse polarity, and tone on 4-pair cables.

Appendix A

Product List and General Description

Product Number	Description
OR-62700021	Dual RJ25C Jacks (VOICE)
OR-40300182	Single gang face plates

OR-40300183	Dual gang face plates
OR-40700072	1.59 cm medium bezel for cubicles

BIX

Northern Telecom Number	Description
A0270164	QMBIX10A 250 pair distribution frame
A0340836	QMBIX12E 300-pair distribution frame
A0266828	QMBIX1A5 25-pair distribution connector (5pr)
A0393146	QMBIX1A4 25-pair distribution connector (4pr)
A0270169	QMBIX20A Data plate
A0270168	QMBIX19A Distribution ring
P0748006	QCBIX1A4 Label, Blue
P0588406	QCBIX1A Label, White
P0748019	QCBIX1A Label, Grey

Station Cable

Product Number	Description
230282	Berktek 4 Pair Category 3 Voice (PLENUM)

Riser Cable

The following manufacturers provide an acceptable Multipair Riser cable product for use throughout the Maine Medical Center campus. Each manufacturer noted below may provide any of the mulitipair cables noted in the description field below. Prior to any installations, All vendors shall provide Maine Medical Center's Telecommunications Department with the complete Manufactuers specifications for the intended product.

Manufactuer	Description
Ortronics	25 Pair
Berk-Tek	50 Pair
General	100 Pair
Superior	200 Pair
Mohawk	300 Pair
Essex	400 Pair

END OF SECTION 16715

SECTION 16725 - NURSE CALL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes audiovisual equipment using voice communications and microprocessor control. All stations in an area are connected to a master station. Master stations are capable of communicating selectively with each other and with connected patient and other stations.

1.3 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. Station Installation Details: For built-in equipment; dimensioned and to scale.
4. Equipment Cabinet Drawings: Dimensioned and to scale.

C. Coordination Drawings: Detail system components that fit, match, and line up with provisions made in equipment specified in other Sections or in separate contracts:

1. Patient head-wall units.
2. Patient consoles.
3. Patient beds with built-in nurse call features.

D. Product Certificates: Signed by manufacturers of nurse call equipment certifying that products comply with requirements.

E. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements. On request, submit evidence of experience and of relationship with equipment manufacturer.

F. Manufacturer Certificates: Signed by manufacturers certifying that they comply with requirements.

G. Field Tests Reports and Observations: Include record of final adjustments certified by Installer.

H. 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.

1.4 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.

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.

C. Source Limitations: Obtain nurse call 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.

1.5 COORDINATION

A. Coordinate patient control units with items controlled that are not part of nurse call equipment.

1. TV: Channel selection and volume

2. Patient ambient and reading light controls.

B. Coordinate wiring paths and maintenance access at locations listed below. Coordinate trim features and finishes at these locations to present a unified design appearance.

1. Patient head-wall units.
2. Patient consoles.

3. Patient beds with built-in nurse call features.

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. Lamps for Corridor Dome Lights and Zone Lights: Furnish quantity equal to 20 percent of amount installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Rauland-Borg Corp.

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. Expansion Capability: Equipment ratings, housing volume, spare keys, switches, relays, annunciator modules, terminals, and cable conductor quantities adequate to increase the number of stations in the future by 25 percent above those indicated without adding internal or external components or main trunk cable conductors.

C. Existing System Compatibility: Functionally and electrically compatible with existing system so components and wiring operate as an extension of the existing system and all functional performance of the existing system applies to the final system. Colors, tones, types, and durations of signal manifestation are common between new and existing systems.

D. 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.

E. Equipment: Solid state, modular.

F. Wall-Mounted Component Connection Method: Components connect to system wiring in back boxes with factory-wired plug connectors.

2.3 FUNCTIONAL PERFORMANCE

A. Patient Station Call: Lights a steady call-placed lamp on the station, steady lamps in the zone light and corridor dome light associated with the patient's room, and steady lamps at the central annunciator and master and staff/duty stations. At the same time, it sounds a distinctive tone at intervals, at the central annunciator and master and staff/duty stations. Legends at the central annunciator and master station identify the calling station.

B. Pull-Cord Station Call: Flashes a call-placed lamp on the station and distinctive-color lamps in the zone light and corridor dome light and at the central annunciator and staff/duty stations. At the same time, it sounds a distinctive tone at intervals, at the central annunciator and master and staff/duty stations. A legend at the master station identifies the calling station.

C. Emergency-Call Station Call: Produces the same responses as pull-cord station calls, except flashing and tone repetition rates are more frequent, tone frequency is higher, and lamps in the zone light and corridor dome light are a different color. Indicator lamps may be extinguished and the system reset only at the calling station.

D. System Reset: Operating reset button at the originating station cancels signals associated with the call.

E. Cord-Set Removal: A patient station call is initiated when the cord set is removed from the jack in the patient station faceplate. Inserting a cord-set plug or a dummy plug into the jack and operating the station reset button reset the call.

F. Patient Control Unit: Controls entertainment volume and channel selection. Nurse button on the unit initiates a patient station call. Integral speaker reproduces entertainment sound.

2.4 FUNCTIONAL PERFORMANCE

A. Station Selection: Master station is capable of selectively communicating with other stations or groups of stations on its system by operating selector switches.

B. Master Station Privacy: Capable of conversing with individual stations in complete privacy.

C. Hands Free: Called station is capable of conversing hands free.

D. Annunciation: At the master station, a tone announces an incoming call and an annunciator light or liquid-crystal display identifies the calling station and indicates the priority of the call. Memory lamps or lighted displays identify stations selected for outgoing calls.

E. System Reset at Master Station: A normal incoming call is canceled, associated lights and audible tones are extinguished, and the system is reset when the station switch is returned to the normal position after responding to a call.

F. Patient Station Call: Lights the call-placed lamp at patient station, zone, and corridor dome lights. It sounds a tone and lights the call lights at staff/duty stations and actuates annunciation at the master station. When the calling station is selected at the master station, the patient can converse with the master station without moving and without raising or directing the voice. During voice communications, entertainment audio at the calling station is automatically muted.

G. Pull-Cord Call Station and Emergency-Call Station Call: Lights call-placed lamp and corridor dome light, and flashes zone light. Master station tone pulses and annunciator light for that room flashes. When master station acknowledges the call by operating a switch, the tone stops but lights continue to flash until the call is canceled at the point of origin.

H. Staff/Duty Station Call: Lights the call-placed lamp at the station and actuates annunciation at the master station. When the called station is selected at the master station, the caller and the master station operator can converse.

I. Handset Operation: Lifting handset on master station disconnects speaker microphone and transfers conversation to the handset.

J. Station Privacy: No patient, staff, or duty station can be remotely monitored without the lighting of a warning lamp at the monitored station.

K. Patient Station Cord Set: When a patient station cord-set plug is removed from the jack in the station faceplate, a patient station call is initiated as described above. When the master station call button for the station is pressed, the tone stops but lights continue to flash until the call is canceled at the point of origin or the plug is reinserted or replaced with a dummy plug.

L. Patient Control Unit: Controls entertainment volume and channel selection. Speaker is used for both nurse communication and entertainment sound. Entertainment sound is automatically muted when station is communicating with master station. Nurse button on the unit initiates a patient station call.

M. Noise: System is free from pops, clicks, hisses, hums, and other noise at all speakers and handsets during operation, including standby.

N. Selective Paging: Master station is capable of initiating a message to selected groups of stations or speakers simultaneously by using station group switches.

O. Staff Reminder: Master station can initiate a staff reminder that a patient requires direct staff response by operating a reminder control while in contact with the patient station. This will light a distinctive-color lamp in the corridor dome light at the patient's room

and in the appropriate zone lights. Reminder calls are canceled by operating a staff reminder cancel switch in the patient's room.

P. Call Priority Indication: Call priority switch near each patient station, or integral with the master station, controls the priority status of the call transmitted by individual stations. The switch selects one of the following status levels:

1. Normal: No change to the normal call initiation and canceling sequence.
2. Emergency: Call initiation produces signals and indications identical to those of emergency-call stations. Indicator lamps are extinguished and the system is reset only at the originating station.
3. Priority: System response is the same for emergency status, except voice communication between the master station and the calling station is locked in from the time of call initiation until the system is reset at the originating station.

2.5 EQUIPMENT DESCRIPTIONS

A. Master Station: NCTSM Touch screen console.

1. Self-contained unit with touch screen display, handset, & dial-pad.

2. Station Selection Controls: Switches select stations for two-way voice communications.
3. Signal Tones: Announce incoming calls.

    a. Pulse rate and frequency of tone identify the highest priority call awaiting response at one time.

4. Volume Control: Regulates incoming-call volume.
5. Speaker-Microphone Sensitivity: At least 40 dB (EIA pressure rating).
6. Privacy Handset with Hook Switch: Attached to each station, unless otherwise indicated.
7. Staff Reminder Control: Initiates flashing of corresponding corridor dome lights for patients requiring service. Permits scanning equipment to indicate which patients are currently in reminder status.
8. Call Priority Selection: Controls associated with patient station selection switches determine the priority indication displayed when a call is initiated at a patient station.

B. Single-Patient Station: NCBSS1 - Speaker microphone with 2-inch (50-mm) dynamic cone, a polarized receptacle to match the cord-set plug, monitor lamp, reset switch, and call-placed lamp; assembled under a single faceplate.

C. Duty Station: NCDUTY - Audible call-tone signal device, speaker microphone with 2-inch (50-mm) dynamic cone, monitor lamp, reset switch, routine-call lamp, emergency-call lamp, and call push button; assembled under a single faceplate.

D. Staff Station: NCSTAFF - Audible call-tone signal device, speaker microphone with 2-inch (50-mm) dynamic cone, monitor lamp, reset switch, routine-call lamp, emergency-call lamp, and call push button; assembled under a single faceplate.

E. Staff Assist Station: NCSPB1 – Single pushbutton station, labeled "STAFF ASSIST", with call placed lamp and "CANCEL" call button.

F. Staff Station/Code Blue: NCDPB2 – Dual pushbutton station, with two buttons labeled "STAFF ASSIST" and "CODE", with call placed lamp for each and "CANCEL" call button.

2.6 MISCELLANEOUS EQUIPMENT COMPONENT DESCRIPTIONS

A. Pull-Cord Call (Toilet/Shower) Station: NCPCS1 - Water-resistant construction. Includes the following, mounted under a single faceplate:

1. Pull-down Switch: Lever-locking type, labeled "Pull Down to Call Help."
2. Reset trigger.
3. Call-placed lamp.

B. Patient Control Unit: Equipped with plug and 96-inch- (2400-mm-) long white cord.

1. Ethylene oxide, sterilizable.
2. Integral Speaker: 2 inches (50 mm), with 0.35-oz. (9.9-g) magnet, rated 0.2 W.
3. Controls: Speaker volume, TV control, and nurse call.
4. Housing: High-impact white plastic.
5. Attachment: Stainless-steel bed clamp with permanently attached Mylar strap.
6. Quantity: 12 units for every 10 patient beds.

C. Call-Button Cord Set: Plug and 72-inch (1800-mm) white cord; equipped with momentary-action, call-button switch.

1. Ethylene oxide, sterilizable.
2. Washable cord.
3. Palladium switch contacts in high-impact white housing with cord-set strain relief.
4. Attachment: Stainless-steel bed clamp with permanently attached Mylar strap.
5. Quantity: 3 cord sets for every 10 patient beds.

D. Call-Button Plug: Designed to plug into patient station cord-set receptacle. Button switches call circuit. Furnish 2 plugs for every 10 patient beds.

E. Dummy Plugs: Designed to plug into patient station cord-set receptacle when call-button plug or patient cord set is not used. Furnish 3 plugs for every 10 patient beds.

F. Indicator Lamps: Light-emitting-diode type with 20-year rated life, unless otherwise indicated.

G. Equipment Mounting Provisions: Suit mounting arrangement indicated.

H. Station Faceplates: Type 302 stainless steel, 0.0375-inch (0.95-mm) minimum, on brushed finish. Machine-engraved labeling identifies indicator lamps and controls.

I. Station Faceplates: High-impact plastic, beige color. Molded or machine-engraved labeling identifies indicator lamps and controls.

J. Corridor Dome Lights and Zone Lights: NCCLS6 – Corridor light with 6 positions.

1. Lamps: Front replaceable without tools, low voltage with rated life of 7500 hours. Barriers are such that only one color is displayed at a time.
2. Lenses: Heat-resistant, shatterproof, translucent polymer that will not deform, discolor, or craze when exposed to hospital cleaning agents.

K. Fire/Auxiliary Module: NC4JACK/NCFAM – Interface external latching alarm contacts.

1. Module shall be provided for medical device monitoring capability as shown on contract drawings.

L. Cable:

1. There shall be two types of networks running concurrently within the system:
   a. Hub controller to hub controller wiring shall be Category 5, 2 pair 22 AWG.
   b. Hub controller to control station shall be Category 3, 3 pair 24 AWG, and 2 conductor 14 AWG (or smaller depending on cable run length) for up to 12 control stations and associated sub-stations.
2. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
3. Shielding: For speaker-microphone leads and elsewhere if recommended by the manufacturer; No. 34 AWG tinned, soft-copper strands formed into a braid or approved equivalent foil. Shielding coverage not less than 60 percent.
4. Listed and labeled for plenum installation.
5. The contractor shall perform all terminations and labeleing for cabling and devices installed, which shall include X-Bus, J-Bus, J-Drops, Sub-Stations, and Power.

M. Grounding Components: As specified in Division 16 Section "Grounding."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wiring Method: Install wiring in cable management system except within consoles, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

B. 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 (150 mm) from cabinets, boxes, or fittings.

C. 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.

D. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power-wiring runs. Run in separate raceways or, if exposed or in same enclosure, provide 12-inch (300-mm) minimum separation between conductors to speaker microphones and adjacent parallel power and telephone wiring. Provide separation as recommended by equipment manufacturer for other conductors.

E. 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.

F. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks if required.

G. 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. Origination (cabinet) and termination (station) points shall be identified.

H. All cables shall be labeled with a unique ID for each cable with corresponding labels at the cabinet (origination) and station ends. Final connection to the live system shall only be performed by MMC technicians or their approved designee.

I. The Labeling sequence that shall be utilized shall be as follows: (See Examples Below)

- X-Bus = From Device #1 to Device #2
- J -Bus = GCM, J-Bus, Device (15-1-1)
- Power = Power Supply #, Power Run #, Power Supply In, Power Supply Out (PS #1, PR #1, PS-In) - (PS #1, PR #1, PS-Out)

J. All cable shall be placed along established cable pathways without weaving between pipes, conduit, etc. All direction changes shall be at ninety (90) degree angular turns. Cabling shall not be run in the same conduit with other systems (i.e. Class 1 AC power distribution, fire alarm entertainment systems, lighting controls, etc.). Consult the BICSI Telecommunications Design Manual (TDM) for clarification of these requirements.

3.2 PROGRAMMING

A. All programming to nurse call systems at MMC by outside contractors must be approved by MMC prior to being performed. Under no circumstances will any programming to the nurse call systems be performed without prior approval from the TNS department at MMC.

B. For project related installations, all initial programming must be approved by MMC personnel prior to implementation. Any "follow up" programming changes needed after the installation must also be approved by MMC personnel prior to actual work performed. All other programming performed on the Rauland systems at MMC must be accompanied by an MMC work order describing the type of programming needed. All programming must also be documented using the process described below in section 3.

C. All programming shall be performed by MMC technicians or their designee. Any programming performed by designee MUST be accompanied by the factory programming forms. These forms shall be completed in as much detail as possible indicating work performed, date, requestor, etc. These forms are contained in Appendix A of the Rauland Responder IV Applications Manual, Section KI1970A.

3.3 EXISTING SYSTEMS

A. Examine existing systems for proper operation, compatibility with new equipment, and deficiencies. If discrepancies or impairments to successful connection and operation of interconnected equipment are found, report them and do not proceed with installation until directed. Schedule existing systems' examination so there is reasonable time to resolve problems without delaying construction.

3.4 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 16 Section "Grounding."

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. Perform tests that include originating station-to-station and all-call messages and pages at each nurse call station. Verify proper routing, volume levels, and freedom from noise and distortion. Test each available message path from each station on the system.
4. Frequency Response Test: Determine frequency response of two transmission paths by transmitting and recording audio tones. Minimum acceptable performance within 3 dB from 150 to 2500 Hz.
5. Signal-to-Noise Ratio Test: Measure the ratio of signal to noise of the complete system at normal gain settings, using the following procedure:

    a. Disconnect a speaker microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure the ratio of signal to noise and repeat the test for four speaker microphones.
    b. The minimum acceptable ratio is 35 dB.

6. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 150, 200, 400, 1000, and 2500 Hz into each nurse call equipment amplifier, and measure the distortion in the amplifier output. The maximum acceptable distortion at any frequency is 5 percent total harmonics.

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.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative (must be a Rauland employee certified on the Responder IV system) to train Owner's maintenance personnel and caregiver 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 eight hours' training.
3. Train Owner's caregiver personnel on proper use of the equipment. Coordinate periods of training with Architect to ensure nursing shifts receive the required training. Conduct training outside normal working hours as required to coordinate with shift schedules. Include instructions utilizing audio and visual graphics and hands-on operation of the equipment in typical zones selected by Architect. Provide handout material describing equipment features and functions to those at-

tending. Provide a minimum of three, three-hour sessions for each group of trainees.

4. Training Aids: Use approved maintenance manual material as instructional aids. Refer to Division 1 Section "Contract Closeout." Provide copies of this material for use in the instruction.

3.7 ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels and controls to suit actual occupancy conditions. Provide up to three visits to Project site for this purpose.

END OF SECTION 16725

SECTION 16726 - PUBLIC ADDRESS SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes equipment for amplifying, distributing, and reproducing sound signals.

1.3 DEFINITIONS

A. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.

B. Zone: A separate group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

C. VU: Volume unit.

1.4 PERFORMANCE REQUIREMENTS

A. System Functions: Include the following:
   1. Selectively connecting separate zones to different signal channels.
   2. Selectively amplifying sound among various microphone outlets and other inputs.
   3. Communicating simultaneously to all zones regardless of zone or channel switch settings.
   4. Paging, by dialing an extension from any local telephone instrument and speaking into the telephone.
   5. Producing a program-signal tone that is amplified and sounded over all speakers, overriding signals currently being distributed.
   6. Reproducing high-quality sound that is free from noise and distortion at all loudspeakers at all times during equipment operation, including standby mode with inputs off; and output free from nonuniform coverage of amplified sound.

1.5 SUBMITTALS

A. Product Data: For each type of equipment.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location of each field connection.
   1. Console layouts.
   2. Control panels.
   3. Rack arrangements.
   4. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring. Identify terminals to facilitate installation, operation, and maintenance. Include a single-line diagram showing cabling interconnection of components.

C. Calculations: For sizing backup battery.

D. Product Certificates: Signed by manufacturers of equipment certifying that products furnished comply with specified requirements.

E. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements.

F. Manufacturer Certificates: Signed by manufacturers certifying that they comply with requirements.

G. Field Test Reports: Indicate and interpret test results for compliance with performance requirements. Include record of final speaker-line matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.

H. Maintenance Data: For equipment to include in maintenance manuals specified in Division 1.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of equipment manufacturer for both installation and maintenance of equipment required for this Section.

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.

C. Comply with NFPA 70.

D. Comply with UL 50.

1.7 OCCUPANCY ADJUSTMENTS

A. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions. Provide up to three on-site assistance visits within one year of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Valcom.

2.2 EQUIPMENT

A. Coordinate features to form an integrated system. Match components and interconnections for optimum performance of specified functions.

B. Equipment: Modular type, using solid-state components, fully rated for continuous duty, unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.

C. Component Listing:

Part Number	Discription	Power Units
V-1020C	8" ceiling speaker	-1
V- 1030C-GY	5 Watt Horn	-6
V- 1036C-GY	15 Watt Horn	-18
V-9914M-5	Bridges	
V-9915M-5	Backboxes	
VP-1124	Power Supply	+20
VP-2124	Power Supply	+40
VP-4124	Power Supply	+80
VP-6124	Power Supply	+120
VP-12124	Power Supply	+240

2.3 PREAMPLIFIERS

A. Comply with EIA SE-101-A; either separately mounted or as an integral part of power amplifier.

B. Output Power: Plus 4 dB above 1 mW at matched power-amplifier load.

C. Total Harmonic Distortion: Less than 1 percent.

D. Frequency Response: Within plus or minus 2 dB from 20 to 20,000 Hz.

E. Input Jacks: Minimum of two. One matched for low-impedance microphone; the other matchable to cassette deck, CD player, or radio tuner signals without external adapters.

F. Minimum Noise Level: Minus 55 dB below rated output.

G. Controls: On/off, input levels, and master gain.

2.4 POWER AMPLIFIERS

A. Comply with EIA SE-101-A.

B. Mounting: Rack mounted.

C. Output Power: 70-W balanced line.

D. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.

E. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.

F. Total Harmonic Distortion: Less than 3 percent at rated power output from 50 to 12,000 Hz.

G. Output Regulation: Less than 2 dB from full to no load.

H. Controls: On/off, input levels, and low-cut filter.

I. Input Sensitivity: Matched to preamplifier and providing full-rated output with a sound-pressure level of less than 10 dynes/sq. cm impinging on a speaker microphone or hand-set transmitter.

2.5 TRANSFER TO STANDBY AMPLIFIER

A. Monitoring Circuit and Sensing Relay: Arranged to detect reduction in output of power amplifier of 40 percent or greater and, in such event, transfer load and signal automatically to standby amplifier.

2.6 COMPONENTS

A. Microphone: Comply with EIA SE-105.
   1. Type: Dynamic, with cardioid polar or omnidirectional characteristic.
   2. Impedance: 150 ohms.

3. Frequency Response: Uniform, 60 to 12,000 Hz.
4. Output Level: Minus 58 dB minimum.
5. Finish: Satin chrome.
6. Mounting: Desk stand with integral-locking, press-to-talk switch.
7. Quantity of Microphones: Four, including one spare.
8. Quantity of Desk Stands: Three.

B. Volume Limiter/Compressor: Equip each zone with a volume limiter/compressor. Install in central equipment cabinet. Arrange to provide a constant input to power amplifiers.
1. Frequency Response: 45 to 15,000 Hz, plus or minus 1 dB minimum.
2. Signal Reduction Ratio: At least a 10:1 and 5:1 selectable capability.
3. Distortion: 1 percent, maximum.
4. Rated Output: Minimum of plus 14 dB.
5. Inputs: Minimum of two inputs with variable front-panel gain controls and a VU or dB meter for input adjustment.

C. Control Console: Modular, desktop cabinet; complying with EIA-310.
1. Housing: Steel, 0.0478 inch (1.2 mm) minimum, with removable front and rear panels. Side panels are removable for interconnecting side-by-side mounting.
2. Panel for Equipment and Controls: Each module is nominal 19 inches (483 mm) wide by 8-3/4 inches (222 mm) high.
3. Controls: Include the following:
    a. Switching devices to select signal sources for distribution channels.
    b. Program selector switch to select source for each program channel.
    c. Switching devices to select zones for paging.
    d. All-call selector switch.
4. Indicators: A visual annunciation for each distribution channel to indicate source being used.
5. Self-Contained Power and Control Unit: A single assembly of basic control, electronics, and power supply necessary to accomplish specified functions.
6. Spare Positions: 20 percent spare zone control and annunciation positions on console.
7. Microphone jack.

D. Telephone Paging Adapter: Arranged to accept voice signals from telephone extension dialing access and to automatically provide amplifier input and program override for preselected zones.
1. Minimum Frequency Response: Flat, 200 to 2500 Hz.
2. Impedance Matching: Adapter matches telephone line to public address equipment input.

E. Equipment Cabinet: Comply with EIA-310-D. House amplifiers and auxiliary equipment at each location.
1. Cabinet Housing: Construct of 0.0478-inch (1.2-mm) steel, minimum, with front- and rear-locking doors and standard EIA 19-inch (483-mm) racks. Arrange for floor or wall mounting as indicated. Size to house all equipment indicated plus

spare capacity. Include 20 percent minimum spare capacity for future equipment over and above space required for future cassette deck and CD player.

2. Power Provisions: Install a single switch in cabinet to supply cabinet power distribution system and electrical outlets, uniformly spaced, to accommodate ac-power cords of each item of equipment.
3. Ventilation: A low-noise fan for forced-air cabinet ventilation. Equip fan with a filtered input vent and connect to operate from 105- to 130-V ac, 60 Hz; separately fused and switchable and arranged to be powered when main cabinet power switch is on.

F. Monitor Panel: A monitor panel mounted above amplifiers.
1. Equip with a VU or dB meter, a speaker with volume control, and a multiple-position rotary selector switch.
2. Connect selector switch and volume control to permit selective monitoring of output of each separate power amplifier via a VU or dB meter and speaker.

G. Cone-Type Loudspeakers: Comply with EIA SE-103.
1. Minimum Axial Sensitivity: EIA pressure rating of 45 dB.
2. Frequency Response: Within plus or minus 3 dB from 50 to 15,000 Hz.
3. Size: 8 inches (200 mm) with 1-inch (25-mm) voice coil and minimum 5-oz. (140-g) ceramic magnet.
4. Minimum Dispersion Angle: 100 degrees.
5. Rated Output Level: 10 W.
6. Matching Transformer: Comply with EIA-160. Full-power rated with four EIA standard taps. Maximum insertion loss of 0.5 dB.
7. Surface-Mounting Units: Ceiling, wall, or pendant mounting, as indicated, in steel back boxes, acoustically dampened. Front face of at least 0.0478-inch (1.2-mm) steel and whole assembly rust proofed and shop primed for field painting.
8. Flush-Ceiling Mounting Units: In steel back boxes, acoustically dampened. Metal ceiling grille with baked, white-enamel finish.

H. Noise-Operated Gain Controller: Units continuously sense space noise level and automatically adjust signal level to local speakers.
1. Frequency Response: 20 to 20,000 Hz, plus or minus 1 dB.
2. Level Adjustment Range: 20 dB minimum.
3. Maximum Distortion: 1 percent.
4. Control: Permits adjustment of sensing level of device.

I. Volume Attenuator Stations: Wall-plate-mounted autotransformer type with paging priority feature.
1. Wattage Rating: 10 W, unless otherwise indicated.
2. Attenuation per Step: 3 dB, with positive off position.
3. Insertion Loss: 0.4 dB maximum.
4. Attenuation Bypass Relay: Single pole, double throw. Connected to operate and bypass attenuation when all-call, paging, program signal, or prerecorded message features are used. Relay returns to normal position at end of priority transmission.
5. Label: "PA Volume."

J. Battery Backup Power Unit: Rack-mounted unit consisting of time-delay relay, sealed lead-calcium battery, battery charger, on/off switch and "normal" and "emergency" indicating lights, and adequate capacity to supply maximum equipment power requirements for one hour of continuous full operation.
   1. Arrange unit to supply public address equipment with 12- to 15-V dc power automatically during an outage of normal 120-V ac power.
   2. Arrange for battery to be on float charge when not supplying system and to transfer automatically to supply system after three to five seconds of continuous outage of normal power, as sensed by time-delay relay.
   3. Automatic retransfer of system to normal supply when normal power has been reestablished for three to five seconds continuously.

K. Cable and Conductors: Jacketed, twisted-pair and twisted-multipair, untinned, solid-copper conductors.

   1. Insulation for Wire in Conduit: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
   2. All cabling shall be terminated by the contractor on contractor-provided and installed BIX style connection blocks as noted in Section 2.01A-E. Two types of cables are available and shall be specified on the project plan. Use one 4-pair Category 3 gray UTP cable for plenum applications.
   3. Microphone Cables: Neoprene jacketed, not less than 2/64 inch (0.8 mm) thick over shield with filled interstices. Shield No. 34 AWG tinned, soft-copper strands formed into a braid or approved equivalent foil. Shielding coverage on conductors is not less than 60 percent.
   4. All paging system wiring shall be listed and labeled for plenum installation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment to comply with manufacturer's written instructions.

B. Wiring Method: Install wiring in raceway except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum-board partitions where cable wiring method may be used. Conceal cable and raceway except in unfinished spaces.

C. Install exposed cables parallel and perpendicular to surfaces or exposed structural members, and follow surface contours. Secure and support cables by straps, staples, or similar fittings so designed and installed to avoid damage to cables. Secure cable at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, or fittings.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess. Use lacing bars in cabinets.

E. Control-Circuit Wiring: Install number and size of conductors as recommended by system manufacturer for control functions indicated.

F. Each speaker cable shall be home run to the telecom closet on the corresponding floor.

G. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

H. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. All cables will be terminated in the telecom closet on a separated BIX style connection block clearly marked "Paging".

I. All speakers will be marked on the outside grill with the matching cable identification.

J. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

K. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables to identify media in coordination with system wiring diagrams.

L. Wall-Mounting Outlets: Flush mounted.

M. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 18 AWG and conductors from microphone receptacles to amplifiers not smaller than No. 22 AWG.

N. Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.

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 impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

C. Install grounding electrodes as specified in Division 16 Section "Grounding."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installations, including connections. Report results in writing.

B. Operational Test: Perform tests that include originating program and page material at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and freedom from noise and distortion.

C. Signal-to-Noise Ratio Test: Measure the ratio of signal to noise of complete system at normal gain settings, using the following procedure:
   1. Disconnect a microphone at the connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure the ratio of signal to noise.
   2. Repeat test for each separately controlled zone of loudspeakers.
   3. Minimum acceptance ratio is 50 dB.

D. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure the distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.

E. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use a sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in the same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.

F. Power Output Test: Measure electrical power output of each power amplifier at normal gain setting at 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.

G. Signal Ground Test: Measure and report ground resistance at pubic address equipment signal ground. Comply with testing requirements specified in Division 16 Section "Grounding."

H. Retesting: Correct deficiencies, revising tap settings of speaker-line matching transformers where necessary to optimize volume and uniformity of sound levels, and retest. Prepare written record tests.

I. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

J. Schedule tests with at least seven days' advance notice of test performance.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain equipment as specified below:
   1. Train Owners maintenance personnel on programming equipment for starting up and shutting down, troubleshooting, servicing, and maintaining equipment.
   2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
   3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 16726