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1.01 RELATED DOCUMENTS

A. This Section is coordinate with and complementary to the General Conditions and Supplementary General Conditions of the Work, wherever applicable to Mechanical Work.

B. Section 01 31 46 – Special Requirements for Mechanical and Electrical Work shall apply.

1.02 SCOPE OF WORK

A. The following work outlined herein shall be performed by the Fire Protection Contractor in accordance with the Contract Documents.

1. Interim alteration work, removal, replacement, relocation, etc. to the existing sprinkler system in the renovated areas as indicated on the drawings.

2. Provide sprinkler piping system including sprinkler heads, control valves, flow and tamper alarms, all required accessories.

3. Hangers and supports.

4. Rough patching, prime painting.

5. Apply for, obtain and pay for all permits, certificates, inspections and approvals required in connection with the fire protection systems.

6. Shop drawings, samples, instructional manuals, tests and adjustments.

7. Color coding and stenciling of piping system.

8. Tests for all systems provided under this Section of the Specifications.

9. Coordination of work with other related trades.

10. Provide all miscellaneous iron and steel as required by this Contractor for proper installation of the work.

11. Obtain approval of all applicable authorities and Owner’s insurance carrier. Shop drawings shall be approved by these authorities before submission to the Architect.

1.03 WORK NOT INCLUDED

A. The following work is not included in the fire protection contract

1. Incoming water services, backflow preventers. See plumbing drawings.

2. Power and fire alarm wiring - see Division 26.

3. Finish patching and painting.

4. Fire extinguishers and extinguisher cabinets.

5. Installation of access doors.

6. All alarm wiring.

1.04 RELATED DOCUMENTS

A. This Section is coordinated with and complementary to the General Requirements and Supplementary General Requirements of the Work, wherever applicable to Mechanical Work.
B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

1.05 SUBMITTALS

A. Submit shop drawings prior to installation covering the following items:
   1. Sprinkler equipment including sprinkler heads, drain connections.
   2. Pipe and fittings.
   3. Sleeves and escutcheons.
   4. Hangers and supports.
   5. Detailed FM 200 system piping layout, including tanks and all accessories.
   6. Detailed sprinkler piping layout, coordinated with all other trades.
   7. Detailed coordinated sleeves and insert drawings for approval by Structural Engineer. In addition, the Contractor shall indicate all piping sleeved through beams.

B. The above listed items are to be considered major equipment and do not limit the Contractor's responsibility from submitting shop drawings for all equipment and accessories which are to be provided under this Section of the Contract.

1.06 JOB CONDITIONS

A. Before starting any Work, consult Architect's detailed drawings and structural drawings, for spaces and headroom allowed for the installation of all piping, equipment, etc. Should any piping or equipment require more space than allowed for, or available headroom as planned, the contractor shall call the Architect's attention to same and obtain his approval before installing the Work.

1.07 INTENT OF SPECIFICATIONS

A. The Specification is neither intended to describe, nor the Drawings to show, in detail the various items of equipment, or the connection thereto. Supply and install all equipment, accessories, supports, pipe connections, fittings, valves, controls, testing, etc., as herein specified or required to make the systems complete and ready for proper operation.

1.08 ACCESSIBILITY

A. The Contractor shall fully inform himself regarding any special characteristics and limitations of the space available for the installation of all materials under Sprinkler Work.

B. The Contractor shall ascertain that all his equipment, such as valves, as may be necessary to be reached from time to time for operation and maintenance, is made easily accessible for operation and maintenance.

C. The location of equipment on the Sprinkler Drawings may conflict with the building construction and may disclose the fact that the location of this Work does not make its position easily and quickly accessible. The Contractor shall call the Architect's attention to this fact before installing this Work, and shall be guided by his instructions.
PERMITS AND CERTIFICATES

A. The Contractor shall give necessary notices, file drawings and Specifications with the departments having jurisdiction, obtain permits or licenses necessary to carry out this work and pay all fees therefore.

DISCREPANCIES

A. The Drawings and Specifications are intended to cooperate. Any materials, equipment, or systems related to this Section and exhibited on the Architectural and Fire Protection Drawings but not mentioned in the Specifications are to be executed to the intent and meaning thereof, as if it were both mentioned in the Specifications and set forth on the Drawings.

B. In case of differences between the Drawings and Specifications, the Specifications shall govern first, and then the Drawings. Large scale details shall take precedence over smaller scale Drawings as to shape and details of construction. Specifications shall govern as to materials.

C. Drawings and Specifications are intended to be fully cooperative and to agree, but should any discrepancy or apparent difference occur between Drawings and Specifications or should occur in the Work of others affecting the work, the Contractor shall notify the Architect at once. If the Contractor proceeds with the Work affected without instructions from the Architect, he shall make good any resultant damage or defect. All misunderstandings of Drawings and Specifications shall be clarified by the Architect.

QUALITY ASSURANCE

A. All materials and equipment used in sprinkler systems shall be UL listed and manufactured in the USA.

B. Standards and Codes
   1. Uniform Construction Code (NJ)
   3. NFPA 13 / 2013 Installation of Sprinkler System
   4. NFPA 14 / 2013 Installation of Standpipe System
   5. NFPA 99 / 2015 Standard for Healthcare Facilities

C. Manufacturer's Instructions
   1. In addition to the requirements of these Specifications, comply with the manufacturer's instructions and recommendations for all phases of the work.

D. All work and material not specifically described, but required for a complete and proper installation of the work of this Section, shall be provided by the Contractor and shall be new, first quality of their respective kinds, and subject to approval of the Architect.

COOPERATION WITH OTHERS

A. The Contractor shall cooperate with other trades whose work is to be correlated with his work, and with the work of each other, in order to avoid field interference, improper elevations, or
inaccessibility to equipment. Any extra expense occasioned by lack of cooperation by this Contractor shall be borne by him.

1.13 EXAMINATION AND COORDINATION

A. The Drawings are diagrammatic and indicate the general arrangement of systems and work indicated under this Section. Do not scale the Drawings. The Contractor shall consult the Architectural Drawings and Details for exact locations of sprinkler heads, lighting fixtures, and HVAC equipment; where same are not definitely located, he shall obtain this information from the Architect.

B. The Contractor shall follow the Drawings in laying out work and check Drawings of other trades to verify spaces in which work will be installed and maintain maximum headroom and space conditions at all points. Where headroom or space conditions appear inadequate, the Architect shall be notified in writing. The installation shall not proceed before receiving the Architect's written instructions.

C. If directed by the Architect, the Contractor shall, without extra charge, make reasonable modifications in the layout as needed to prevent conflict with work of other trades, maintain required headroom and space conditions, or for proper execution of the work.

D. It shall be the responsibility of the Contractor to closely schedule his work so that his work will be installed at the proper time and without delaying the completion of the entire Project.

E. Study the Drawings and Specifications in order to insure completeness of the Work required under this Section. Supplementary items normal and necessary to complete the Work, though not definitely shown or specified shall be included.

F. Verify all measurements and conditions in the field before starting work.

G. Examine all surfaces to which Work under this Section is to be applied and notify the Architect in writing if any conditions exist which are detrimental to the proper and expeditious installation of Work. Starting of Work shall be construed as acceptance of surfaces.

1.14 CLEANING, PROTECTION AND ADJUSTING

A. The Contractor shall be responsible for the protection of all fire protection systems equipment against breakage or damage at all times until final acceptance of the job.

B. All openings left in floor for passage of supply pipes shall be covered and protected. Due precautions shall be taken against freezing during cold weather. All pipes shall be protected with suitable coverings as soon as set. All open of pipes shall be closed by a plug fitting to prevent obstruction and damage.

C. The Contractor shall frequently clean up and remove from the Site all rubbish, scrap materials and debris caused by his Work, and upon completion of the Work and before final payment is made, he shall remove from the site all surplus material, temporary structures, tools and all debris resulting from his operation.
PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION - NOT USED

END OF SECTION 21 05 02
SECTION 21 05 03
APPROVED MANUFACTURERS FOR FIRE PROTECTION WORK

PART 1 - GENERAL REQUIREMENTS

1.01 RELATED DOCUMENTS

A. This Section is coordinated with and complementary to the General Requirements and Supplementary General Requirements of the Work, wherever applicable to Mechanical Work.

B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

PART 2 - PRODUCTS

2.01 APPROVED MANUFACTURERS

A. The manufacturers' names and models hereinafter specified represent a standard of materials, appearance, finishes, performance, etc. Not all manufacturers are listed in this Section. For additional items, see specific sections describing those items.

B. The following is a list of approved manufacturers:

1. Sprinkler Heads
   a. Reliable Inc.
   b. Grinnell
   c. Viking Corp.
   d. Tyco

2. Steel Pipe
   a. Youngstown Sheet and Tube Co.
   b. Republic Steel Co.
   c. National Tube Co.

3. Fittings
   a. Victaulic
   b. Gustin-Bacon
   c. Stockham
   d. Ward

4. Hangers and Supports
   a. Carpenter & Paterson, Inc.
   b. Grinnell
   c. B-Line
   d. Anvil

5. Fire Standpipe Equipment
   a. Potter-Roemer
   b. Croker
   c. Kesson
PART 3 - EXECUTION (NOT USED)

END OF SECTION 21 05 03
PART 1 - GENERAL REQUIREMENTS

1.01 RELATED DOCUMENTS

A. This Section is coordinated with and complementary to the General Requirements and Supplementary General Requirements of the Work, wherever applicable to Mechanical Work.

B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

1.02 SCOPE OF WORK

A. The work of this section includes all labor, tools, appliances, equipment, materials and services required for the work indicated on the drawings and specified in this section, including but is not necessarily limited to, the following:
   1. Sprinkler system equipment and specialties.
   2. Sprinkler hydraulic calculations.

1.03 RELATED WORK:

A. General Provisions for Sprinkler Work Section 21 05 02

B. Wiring Between Alarm Initiating Devices and Alarm Panel Division 26

1.04 QUALITY ASSURANCE

A. All work under this Section of the Specifications shall conform to the NYS Fire Prevention and Building Code, local Fire Department rules and regulations and NFPA 13.

B. The persons installing the specified work and their supervisors shall be personally experienced in the work; and shall have been regularly employed by a firm engaged in the installation of the similar work for a minimum of five (5) years.

C. All materials and equipment shall be UL listed and, where indicated, FM approved.

PART 2 - PRODUCTS

2.01 SPRINKLER HEADS

A. Sprinkler heads shall be cast brass closed type with ½" discharge orifice.

B. Sprinkler heads shall have ordinary degree temperature rating, except that where indicated on the drawings temperature rating shall be 212°F.
C. Sprinkler heads shall be as manufactured by Reliable Automatic Sprinkler Co., or approved equal from one of the acceptable manufacturers listed, and shall be of the following types: See Schedule on Drawings.

D. All sprinkler heads shall be UL listed.

E. Provide sprinkler guards where necessary.

2.02 SPRINKLER CABINET

A. Provide an enameled steel sprinkler cabinet with number and quantity of sprinkler heads as required by NFPA-13, (of all types and rating installed) with two sprinkler wrenches and installed where directed by the Owner.

2.03 TAMPER SWITCHES

A. Tamper switches shall be installed on all valves controlling water supply to the sprinkler system and shall be 120 volts closed circuit supervisory switches having one set of S.P.D.T. contacts.

B. Switches shall be mounted so not to interfere with the normal operation of the valve and shall be adjusted to operate when the stem of the valve has moved no more than one-fifth of the distance from its normal position.

C. The switch mechanism shall be contained in a weatherproof die cast aluminum housing which shall provide a 3/4" tapped conduit entrance and incorporate the necessary facilities for attachment to the valve. Switch housing shall be finished in red baked enamel.

D. The entire installed assembly shall be tamperproof and arranged to cause a switch operation if the housing cover is removed or if the unit is removed from its mounting.

E. Tamper switches for OS&Y valves shall be installed in accordance with requirements of switch manufacturer, local authorities, and underwriters, and shall be similar to Potter Electric Model OSYSU-1 or approved equal product from one the acceptable manufacturers.

F. Butterfly valves shall have approved built-in tamper switches.

2.04 WATER FLOW DETECTORS

A. Water flow detectors shall be installed at each floor control valve assembly and on the sprinkler system piping where indicated on the drawings.

B. Detectors shall be designed for mounting on either vertical or horizontal piping, but shall not be mounted in a fitting or within 12" of any fitting that changes the direction of water flow.

C. Flow switch shall have a sensitivity setting to signal any flow of water that equals or exceeds the discharge from one sprinkler head and shall be closed circuit water flow indicators with retarding device to prevent false alarms from line surges. Switch shall match type and size of pipe and shall have rigid conduit type electrical connections; no plug-in connections shall be permitted.
D. Provide required contacts and relays to actuate central fire alarm panel.

E. Switches shall be similar to Potter Electric Model VSR-F or equal product from one of the acceptable manufacturers with two sets of form “C” S.P.D.T. contacts. Install switches in strict accordance with manufacturer's instructions.

2.05 PRESSURE GAUGES

A. Pressure gauges shall be of a type approved by all authorities having jurisdiction and shall have 3-1/2" dials, cast brass cases and shall be graduated to twice the working pressure.

B. Each gauge shall have a shut-off cock or valve together with a plugged outlet for the connection of an inspector's test gauge.

C. Gauges shall be double spring gauges.

D. Pressure gauges shall be installed at all floor control assemblies.

2.06 DRAIN CONNECTIONS

A. Arrange the installation of piping so that all or any part of the work may be completely drained. Piping shall be pitched so as to drain to the main drain or to auxiliary drains.

B. The main drain shall be arranged so a test through drain pipe can be made without flooding the receptacle.

C. Provide drain valves or plugs with threaded connection at low points of sprinkler systems for drainage as required by code.

2.07 SIGNS, TAGS AND CHARTS

A. Signs: Provide identification signs of standard design, fastened securely at the base of each riser and door of rooms having sprinkler control valve assemblies and as required by NFPA 13.

B. Tags: Provide brass tags 2" in diameter, stamped with designating numbers and secured with 12 gauge copper wire to spindle of all control valves.

C. Chart: Provide required number of copies of approved sprinkler system diagram and valve chart, giving designation number, function, location of each valve, mount in painted, glazed frames and hang where directed by the C.M.

PART 3 - EXECUTION

3.01 SPRINKLER DESIGN CRITERIA:

A. The entire structure shall be provided with automatic sprinklers.

B. The hazard of occupancies for this project is classified Light and Ordinary Group 1 as follows:
1. Ordinary Hazard Group I: Storage rooms, Mechanical Equipment rooms and similar spaces.
2. Light Hazard: Corridors, lobbies, public spaces, offices and similar spaces.

C. The sprinkler systems shall be hydraulically designed in accordance with the following minimum criteria:
   1. Light Hazard Occupancy: 0.10 gpm per square foot over most hydraulically remote 1,500 square feet. Maximum coverage per sprinkler head is 225 square feet.
   2. Ordinary Hazard Group 1: 0.16 gpm per square foot over most hydraulically remote 1,500 square feet. Maximum coverage per sprinkler head is 130 square feet.
   3. Maximum velocity permitted in the piping shall be 20 FPS.
   4. Sprinkler discharge from single sprinklers in closets and toilet rooms may be omitted in hydraulic calculations.

D. Sprinkler Layout and Calculations shall meet the following requirements:
   1. Discharge from each sprinkler head shall not be less than required for area covered by this head.
   2. Area coverage per head shall be determined in accordance with NFPA Standard No. 13.
   3. Minimum pressure at sprinkler head shall be 7 psi or greater, as required for minimum discharge.

3.02 INSTALLATION:

A. Sprinkler heads, in general, shall have ordinary degree temperature rating, but any and all heads subject to abnormal heating conditions, as those in the vicinity of heating units, boilers, or close to hot piping, shall be of sufficiently high temperature rating to prevent their accidental discharge when no fire is present. The head rating at these locations shall be in accordance with NFPA-13.

B. The sprinkler heads are to be installed on a true axis line of ceiling tiles in both directions with a tolerance of ± ½”, except where noted or shown otherwise. At the completion of the installation, if any heads are found to exceed the above, any adjoining work that may be disturbed in reinstating said heads shall be repaired or reinstated at no additional cost to the Owner.

C. The Contractor shall make notifications in respect to location of sprinkler heads, as may be required by field conditions or as may be found necessary by the Engineer at the time of installation. Valves, fittings, hangers, means of draining system, alarm and connections thereto and all necessary appurtenances shall be installed as required. Any changes that may be necessary because of physical conditions or compliance with the standards and requirements of any agency having jurisdiction shall be made by this Contractor without additional cost to the Owner.

D. The floor control valves shall be installed inside of the building at locations as directed. Approved devices shall be installed for the automatic annunciation of the flow or water.

E. The system shall be so installed that no part thereof will interfere with doors, windows, heating, plumbing or electrical equipment, and sprinkler heads shall not be located closer than one foot from lighting fixtures or other obstructions. In connecting therewith, this Contractor shall coordinate his Work with the other trades as to avoid any interference with the potential effectiveness of the automatic sprinkler system and shall prepare and incorporate in composite
working drawings the location of sprinkler heads in relation to other ceiling equipment, piping, ductwork, electrical and other appurtenances which may impact the sprinkler operation.

F. Provide inspector's test connection at the remote end of the system where shown on the drawings.

G. Drains shall be installed at low points of piping to provide for complete draining of the system, as outlined in NFPA-13.

H. Direct connection from any drain to any component of the sanitary drainage system is prohibited.

I. Installation of sprinkler heads in fittings before piping is erected is prohibited.

J. Contractor shall provide flushing connections for flushing scale and foreign material from sprinkler system in accordance with NFPA-13.

K. The complete sprinkler installation shall be made by a licensed sprinkler Contractor specializing in sprinkler work and having not less than ten (10) years experience in installing systems of comparable size.

END OF SECTION 21 05 11
PART 1 - GENERAL REQUIREMENTS

1.01 RELATED DOCUMENTS

A. This Section is coordinated with and complementary to the General Requirements and Supplementary General Requirements of the Work, wherever applicable to Mechanical Work.

B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

1.02 SCOPE OF WORK

A. The work of this section includes all labor, tools, appliances, equipment, materials and services required for the work indicated on the drawings and specified in this section, including but not necessarily limited to, the following:
   1. Valves for sprinkler work

1.03 RELATED WORK:

1. General Provisions for Sprinkler Work Section 21 05 02
2. Pipe and Fitting for Sprinkler Work Section 21 05 28

1.04 QUALITY ASSURANCE:

A. Valves used on the sprinkler systems shall be UL listed.

B. Valves shall have the trademark of the manufacturer and the guaranteed working pressure cast or stamped on the body of the valve.

PART 2 - PRODUCTS

2.01 CONTROL VALVES:

A. Except as noted, all valves controlling water flow in sprinkler piping shall be of the outside screw and yoke (OS&Y) type:
   1. 2" and smaller: threaded bronze, 175 psi wwp, Stockham B-133.
   2. 2½" and larger: flanged, IBBM, 175 psi wwp, except as noted, Stockham G-634.

B. Valves installed on Sprinkler systems as zone control valve may be indicating type butterfly valves, 175 psi wwp, as manufactured by Victaulic or from one of the acceptable manufacturers.
   1. For sizes 2", 2½", 3" - Series 727
   2. For sizes 4" and larger - Series 708

C. All valves controlling flow in sprinkler systems shall be equipped with supervisory tamper switches.
2.02 CHECK VALVES

A. 2” and smaller: swing type, threaded bronze, 175 psi wwp, Stockham B-319.

B. 2½” and larger: swing type, flanged, IBBM, 175 psi wwp, Stockham G-940.

2.03 DRAIN VALVES:

A. Valves for drain and test lines: bronze, globe or angle type, threaded, with appropriate pressure rating, Walworth No. 58 or 59.

2.04 SPRINKLER COMBINATION TEST/DRAIN VALVES

A. Combination fitting including ½” flow orifice, sight glass, test valve, drain valve and 1¼” test/drain connection (2” for sprinkler connections 4” and larger), AFG Model Test-N-Drain, or approved equal.

1. Provide downstream of each water flow switch and where indicated.

2.05 VALVE TAGS:

A. Identification signs indicating the portion of the system controlled by each valve shall be provided. The identification sign should be minimum 25 gauge corrosion resistant metal. If made of corrodeable metal such as steel, the sign should be of the same minimum gauge and completely enameled. Valve control information should be steel-stamped or otherwise permanently marked (e.g., enameled lettering in contrasting color, in characters at least 0.2” high. Embossed plastic tape, pencil, ink, crayon, etc. are not considered permanent markings.) This sign should be secured with durable wire chain.

PART 3 - EXECUTION

3.01 INSTALLATION REQUIREMENTS:

A. Provide ladder or chain operators for all valves located 7'-0" and higher above floor.

B. Installation of Check Valves

1. Swing Check Valves: Install in horizontal position with hinge pin located on the upside of the pipe and perpendicular to the pipe's centerline, or in vertical position with the flow directed upward.

END OF SECTION 21 05 23
SECTION 21 05 28
PIPE, TUBE AND FITTINGS FOR FIRE PROTECTION WORK

PART 1 - GENERAL

1.01 DESCRIPTION
A. This Section is coordinated with and complementary to the General Conditions and Special Conditions of the Work, wherever applicable to Mechanical and Electrical Work.
B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.
C. Section 21 05 02 - General Provisions for Sprinkler Work shall apply.

1.02 SCOPE OF WORK
A. The work of this Contract includes the providing of all labor, materials, accessories, services and tests necessary to install, complete and make ready for operation by the Owner, all work as shown on the Drawings and as specified herein.

1.03 SPECIFIC REQUIREMENTS
A. Pipe and fittings shall conform to the latest USASI, ASTM, ANSI and/or F.S. Standards.
B. All pipes, fittings, traps, materials and/or other devices used in the fire protection systems shall have cast, stamped, or indelibly marked on it the maker's name or mark, weight, and quality of the product when such marking is required by the approved standard.
C. All materials used on sprinkler systems shall be approved by UL and shall have New York City BS&A approval number.

PART 2 - PRODUCTS

2.01 INTERIOR PIPING MATERIAL:
A. Fire standpipe and sprinkler system pipe shall be suitable for 175 psi working pressure in accordance with ANSI B36.10-1979 and any subsequent revisions thereof, and shall be Schedule 40 black steel pipe.
B. Subject to approval, the Contractor has an option of using "lightwall" schedule 10 piping for sizes 2½" and up on the discharge side of the fire pump. The lightwall piping shall be suitable for 175 psi working pressure in accordance with ANSI B36.10-1979.
C. Fittings for standpipe and combined piping shall be specifically approved for use in fire standpipe systems and shall be suitable for 300 psi working pressure and made of malleable iron.
D. Fittings for sprinkler piping shall be UL listed and be of a type specifically approved for use in sprinkler systems suitable for 175 psi working pressure and made of carbon steel, cast iron, ductile iron, or malleable iron, screwed fittings.

E. Subject to approval, the Contractor has the option of using grooved end piping and grooved end fittings with mechanical type coupling for sizes 2½" and up.

F. Grooved end fittings and couplings shall be of the following type and figure number as manufactured by Victaulic. Equal materials manufactured by Grinnell may be submitted for approval. All grooved couplings, fittings, valves and specialties shall be the products of a single ISO 9001 certified manufacturer. Grooving tools shall be of the manufacturer as the grooved components.
   1. Couplings shall be ASTM A395 and A536 ductile iron. Rigid type couplings shall be complete with angle-pattern bolt pads for rigidity and support and hanging requirements corresponding to ANSI B31.1, B31.9, and NFPA 13. Gaskets shall be EPDM.
   2. Fittings shall be ASTM A395 and A536 ductile iron, with grooved ends for use with couplings of the same manufacturer.

G. Grooved end fittings and couplings schedule:

<table>
<thead>
<tr>
<th>Item</th>
<th>Victaulic Fig. N°</th>
<th>To Be Used On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero-Flex Coupling</td>
<td>Firelock 005 or 07</td>
<td>All vertical risers</td>
</tr>
<tr>
<td>Flexible Coupling</td>
<td>75</td>
<td>All horizontal piping</td>
</tr>
<tr>
<td>Vic-Flange Adapter</td>
<td>Firelock 744 or 741</td>
<td>For connection of flanged components into a grooved system</td>
</tr>
<tr>
<td>Elbows</td>
<td>Firelock 001 or 10, 11, 12, 13</td>
<td>Throughout</td>
</tr>
<tr>
<td>Reducers</td>
<td>50, 52</td>
<td>Throughout</td>
</tr>
<tr>
<td>Tees</td>
<td>20</td>
<td>Throughout</td>
</tr>
<tr>
<td>Reducing Tees</td>
<td>25, 29</td>
<td>Throughout</td>
</tr>
<tr>
<td>Cross</td>
<td>35</td>
<td>Throughout</td>
</tr>
<tr>
<td>Mechanical Tee</td>
<td>920 only</td>
<td>Throughout</td>
</tr>
</tbody>
</table>

H. Reducing coupling similar to Victaulic Fig. 750 will not be permitted.

I. Pipes for testing and drainage and for dry pipe system shall be galvanized steel with cast iron screwed drainage fittings.

J. When mechanical groove couplings are installed in dry pipe system, the elastometric gaskets should be specifically listed and FM approved for dry pipe service.

2.02 ESCUTCHEONS

A. Where instructed by the Architect, provide escutcheons on pipes passing through walls, floors, ceiling or partitions.

B. Provide set screw escutcheons to properly fasten same in place.
C. Escutcheons shall be of sufficient diameter to cover the sleeve. They shall be: chrome plated at floors and factory applied matte white enamel at the ceiling.

2.03 NIPPLES

A. No close nipples will be permitted. Short or shoulder nipples with the unthreaded section of the pipe no less than 2" long shall be of extra heavy pipe.

2.04 EXPANSION JOINT

A. Any breaks or damage to the piping system or to the work of other Sections within the period of the guarantee due to improper provisions for expansions and contraction must be replaced at this Contractor's expense.

B. Provide sufficient number of elbow swings to allow for proper expansion and contraction of piping.

PART 3 - EXECUTION (NOT USED)

END OF SECTION 21 05 28
PART 1 - GENERAL REQUIREMENTS

1.01 RELATED DOCUMENTS

A. This Section is coordinated with and complementary to the General Requirements and Supplementary General Requirements of the Work, wherever applicable to Mechanical Work.

B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

C. Section 23 20 00 – Building Structural Attachment Requirements shall apply.

1.02 SCOPE OF WORK

A. The work of this section includes all labor, tools, appliances, equipment, materials and services required for the work indicated on the drawings and specified in this section, including but is not necessarily limited to, the following:

1. Hangers and supports

1.03 RELATED WORK

A. General Provisions for Fire Protection Work Section 21 05 02

B. Pipe, Tube and Fittings for Fire Protection Work Section 21 05 28

1.04 QUALITY ASSURANCE

A. Materials of hangers and supports shall be UL listed and shall comply with ANSI/MSS SP-58, MSS SP-69, MSS SP-89.

B. Assume the responsibility for the proper transfer of the loads of the piping system to the structure. No additional cost to the Owner will be accepted for any corrective work during construction.

C. Supports and hangers shall be provided for all horizontal and vertical piping. The hanger design shall conform to NFPA-13.

D. Bracket clamps and rod sizes indicated in these Specifications are minimum size only. The Contractor shall be responsible for structural integrity of all supports. Structural hanging material shall be able to support five times the weight of water filled pipe plus 250 lb. at each point of piping support and shall be in accordance with current edition of NFPA-13.

E. Pipe supports shall be of type and arrangement as hereinafter specified. They shall be so arranged as to prevent excessive deflection and avoid excessive bending stresses between supports.

F. Sprinkler protection piping shall be independently supported.
PART 2 - PRODUCTS

2.01 HANGERS AND SUPPORTS

A. Pipe supports shall be of the following type and figure number as manufactured by Grinnell, or approved equal product of any other acceptable manufacturer.

B. Pipe Hanger Schedule:

Grinnell

<table>
<thead>
<tr>
<th>Item</th>
<th>Fig. #</th>
<th>Piping Sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Clamp w/locknuts</td>
<td>94 or 133</td>
<td>All</td>
</tr>
<tr>
<td>Beam Clamp w/Retaining Clip</td>
<td>95 &amp; 96</td>
<td>All</td>
</tr>
<tr>
<td>Adjustable Galvanized Clevis Hanger</td>
<td>260</td>
<td>All</td>
</tr>
<tr>
<td>Adjustable Galvanized Swivel Ring</td>
<td>69</td>
<td>2&quot; and smaller</td>
</tr>
<tr>
<td>Riser Clamp</td>
<td>261</td>
<td>All</td>
</tr>
<tr>
<td>Brackets</td>
<td>195, 199</td>
<td>All</td>
</tr>
<tr>
<td>Concrete Insert</td>
<td>281</td>
<td>All</td>
</tr>
</tbody>
</table>

PART 3 - EXECUTION (NOT USED)

END OF SECTION 21 05 29
1.01 RELATED DOCUMENTS
   A. This Section is coordinated with and complementary to the General Requirements and Supplementary General Requirements of the Work, wherever applicable to Mechanical Work.
   B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

1.02 WORK INCLUDED:
   A. The work of this section includes all labor, tools, appliances, equipment, materials and services required for the work indicated on the drawings and specified in this section, including but is not necessarily limited to, the following:
      1. Testing of sprinkler systems

1.03 RELATED WORK:
   A. General Provisions for Sprinkler Work Section 21 05 02.

1.04 REQUIREMENTS
   A. All tests shall be made in the presence of the Architect and representatives of the local authorities having jurisdiction over the work to be tested, as may be directed. At least 72 hours notice shall be given in advance of all tests to all parties required to be present.
   B. Contractor shall include the supplying of all testing instruments, gauges, pumps, and other equipment required or necessary for tests.
   C. Provide all tests required by code and all authorities having jurisdiction.
   D. All appurtenances shall be operated after installation to determine whether or not they meet the requirements of the Specifications.
   E. All defects disclosed in the work by tests and otherwise shall be made good or the Work replaced without additional cost to the Owner.
   F. Tests shall be repeated after any defects disclosed thereby have been made good or the work replaced if it is deemed necessary.
   G. All tests shall be made at the expense of the Contractor.
   H. Tests are not permitted to be made with air.
   I. Contractor shall provide and plug required test fittings during erection of pipe system.
J. If the pipe installation fails to meet testing requirements, the Contractor shall at his own expense locate the leakage(s) and shall repair or replace all defective materials or workmanship. The system shall be retested after completion of the repair/replacement work.

K. Piping which is to be hidden in partitions, furrings or above hung ceilings shall be tested and made tight when directed by the Architect and in adequate time to permit the installation of partitions and ceilings. When necessary, the Contractor shall drain the piping and/or take over such precautions as required to prevent damage by freezing.

L. The Contractor shall also be responsible for the Work of other Contractors that may be damaged or disturbed by the tests, or the repair or replacement of his Work, and he shall, without extra charges, restore to its original condition any Work so damaged or disturbed.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 21 08 00
SECTION 22 05 02
GENERAL PROVISIONS FOR PLUMBING WORK

PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section is coordinated with and complementary to the General Conditions and Special Conditions of the Work wherever applicable to Mechanical and Electrical Work.

B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

1.02 SCOPE OF WORK

A. Except as otherwise specified under "Related Work Not Included", the work of this Contract consists of furnishing all labor, materials, equipment and appliances necessary and required to completely do all Plumbing Work as indicated on the Drawings or described or referred to in the Specifications, including, but not limited to the following:
   1. Interim alteration work, removal, replacement, relocation, etc. to the existing plumbing systems in the renovated areas as indicated on the drawings.
   2. Provide plumbing fixtures and trim.
   3. Provide gravity sanitary, soil, waste and vent piping systems, including all required connections to all plumbing fixtures and equipment.
   4. Provide interior domestic cold and hot water piping systems, and connection to all fixtures and equipment requiring cold and hot water.
   5. Provide interior medical gas piping systems.
   6. Make all plumbing connections required for equipment furnished by Owner and/or under other Divisions or Sections of these Specifications.
   7. Sleeves, hangers and supports.
   8. Insulation for piping and equipment.
   9. Apply for, obtain and pay for all permits, certificates, inspections and approvals required in connection with all Plumbing Work.
   10. Shop drawings, samples and instructional manuals, tests and adjustments.
   11. Provide roughing (water supplies, soil, waste, and vent piping) for all fixtures and equipment by this Division and/or installed under other Divisions or Sections of these Specifications.
   12. Color coding and stenciling of all piping systems.
   13. Cutting and rough patching.
   15. Tests for all systems provided under this Section of the Specifications.
   16. All work described in these Specifications and not shown on the Drawings, or vice versa, shall be installed in a manner similar to the work shown or described.

1.03 RELATED WORK NOT INCLUDED

A. The following principal items of work shall be provided under other Sections:
   1. Finish patching and finish painting.
   2. Installation of access doors.
3. All electrical power wiring conduits, etc., for pumps, equipment, etc., shall be provided under Division 26.
4. Drainage piping from HVAC equipment to and spilling over floor drain, mop sink, sump or roof, except as noted.

1.04 LIST OF SHOP DRAWINGS

A. Submit shop drawings prior to installation covering the following items:
   1. Plumbing fixtures, equipment, plumbing fixture trimmings, shut-off valves, faucets, supports, accessories and traps.
   2. Valve tags, color coding and valve charts.
   3. Insulation for piping and equipment.
   4. All drains including floor, funnel and roof drains.
   5. Sleeves, escutcheons, hangers and inserts.
   6. All types of piping, fittings, valves, etc. with description of intended uses.
   7. Detailed piping layout for all plumbing systems, coordinated with all other trades.
   8. Detailed coordinated sleeves and insert drawings for approval by Structural Engineer. In addition, the Contractor shall indicate all piping sleeved through beams.

B. The above listed items are to be considered major equipment and do not limit the Contractor's responsibility from submitting shop drawings for all equipment and accessories which are to be provided under this Section of the Contract.

1.05 VISITING THE PREMISES

A. This Contractor, before submitting his bid on the work, shall visit the site and familiarize himself with all visible existing conditions. As a result of having visited the premises, this Contractor shall be responsible for the installation of the work as it relates to such visible existing conditions.

B. The submission of a bid will be considered an acknowledgment on the part of the bidder of his visitation to the site.

1.06 QUALITY ASSURANCE

A. Manufacturer's Instructions: In addition to the requirements of these Specifications, comply with the manufacturer's instructions and recommendations for all phases of the work.

B. Standards and Codes
   1. Uniform Construction Code (NJ)
   5. Rehabilitation Sub-Code

C. All work and material not specifically described, but required for a complete and proper installation of the work of this Section, shall be provided by the Contractor and shall be new, first quality of their respective kinds, and subject to approval of the Architect.
D. All water supply connections to plumbing fixtures and other equipment to be installed under this Division shall be in accordance with the rules relative to submerged inlets and protective methods to be applied to prevent contamination of water as required by Local and State Regulations.

1.07 ALTERATION WORK

A. All equipment, piping, plumbing fixtures, etc. to be removed shall be disposed of, turned over to the Owner or salvaged as directed by the Owner. They shall not be removed from the premises without the Owner's approval.

B. All piping to be removed shall be properly plugged or capped so that upon completion of all new work, all abandoned piping shall be concealed in finished areas.

C. No dead ends shall be left on any piping upon completion of job.

D. Existing exposed piping not to be reused and not specifically noted or shown on Drawings to be abandoned shall be completely removed.

E. The existing system shall be left in perfect working order upon completion of all new work.

F. Locations and sizes of existing piping are approximate. Exact sizes and locations of all existing piping shall be verified at the site.

G. No removed existing piping, etc. shall be reused.

H. All existing exposed, unnecessary piping related to work being done shall be completely removed.

I. This Contractor shall not interrupt any of the services of the existing building, nor interfere with the services in any way without the express permission of the Owner. Such interruptions and interferences shall be made as brief as possible and only at the time stated by the Owner.

J. Under no circumstances shall this Contractor or his workmen be permitted to use any part of the premises as a shop, except parts designated by the building for such purposes.

K. Reroute or remove all existing piping where necessary to avoid new equipment, structural or masonry work as required by the proposed alteration.

1.08 CONCRETE WORK

A. All concrete equipment bases that are installed on vibration isolators, all anchor and thrust blocks and all piping supports in trenches shall be provided under the work of this Section. All formed and poured-in-place concrete work including equipment housekeeping pads, sumps, etc., will be provided under another Division or Sections of these Specifications.

B. This Contractor shall furnish all required templates for anchor bolts, and dimension drawings for housekeeping pads and sumps. All concrete provided under the work of this Section shall be in accordance with that specified under another Division or Sections of these Specifications.
1.09  COOPERATION WITH OTHERS

A. The Plumbing Contractor shall cooperate with other trades whose work is to be correlated with his work in order to avoid field interference, improper elevations, or inaccessibility to equipment. Any extra expense occasioned by lack of cooperation by this Contractor shall be borne by him.

END OF SECTION 22 05 02
PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section is coordinated with and complementary to the General Conditions and Special Conditions of the Work, wherever applicable to Plumbing Work.

B. Section 01 31 46 - Special Requirements for Mechanical Work shall apply.

C. Section 22 05 02 - General Provisions for Plumbing Work shall apply.

PART 2 - PRODUCTS

2.01 APPROVED MANUFACTURERS

A. The manufacturers' names hereinafter specified represent a standard of materials, appearance, finishes, and performance.

B. The Plumbing Contractor has the option of submitting other manufacturers for approval in lieu of the manufacturers hereafter specified, provided their respective products conform in all respects to the manufacturers hereafter specified. This conformity must be shown by the Contractor on the submittals item by item.

C. The following is a list of approved manufacturers:

1. Plumbing Fixtures (China)
   a. American Standard
   b. Crane
   c. Kohler

2. Stainless Steel Sinks
   a. Just
   b. Elkay

3. Trim for Plumbing Fixtures and Hose Bibbs
   a. Chicago Faucet
   b. American Standard
   c. T&S Brass
   d. Elkay

4. Hangers and Supports
   a. Anvil
   b. Carpenter & Paterson, Inc.
   c. B-Line Systems
   d. Erico

5. Insulation
   a. Owens Corning Fiberglass Co.
   b. Manville Corp.
   c. Zeston
   d. Certainteed
6. Drains and Plumbing Systems Specialties
   a. Zurn
   b. J.R. Smith
   c. Josam
   d. Wade
   e. Mifab

7. Gate and Check Valves
   a. Stockham
   b. Walworth Co.
   c. Jenkins Bros.
   d. Crane Co.
   e. Nibco
   f. Milwaukee Valves

8. Piping and Fittings (Cast Iron)
   a. Tyler Soil Pipe
   b. Charlotte Pipe and Foundry Co.

9. Pipe (Steel)
   a. Youngstown Sheet and Tube Co.
   b. Republic Steel Co.
   c. Allied Pipe Co.

10. Pipe and Fittings (Copper)
    a. Bridgeport Brass
    b. Mueller Brass Co.
    c. Anaconda American Brass Co.
    d. Chase Brass and Copper Co.
    e. Elkhart

11. Gate and Check Valves
    a. Stockham
    b. Nibco
    c. Kennedy Valve Co.

12. Vacuum Breakers
    a. T&S Brass
    b. Chicago Faucet Co.

13. Thermostatic Mixing Valves
    a. Leonard Valve Co.
    b. Guardian
    c. Armstrong

14. Fixture Stops
    a. Dole
    b. Chicago Faucet

15. Flush Valves
    a. Sloan
    b. Zurn
    c. Delany

END OF SECTION 22 05 03
PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section is to coordinate with and be complementary to the General Conditions and Special Conditions of the work, wherever applicable to Mechanical and Electrical Work.

B. Section 01 31 46 Special Requirements for Plumbing Work shall apply.

C. Section 22 05 02 - General Provisions for Plumbing Work shall apply.

1.02 SCOPE OF WORK

A. The Work of this Contract includes providing all labor, materials, accessories, services and tests necessary to install complete and make ready for operation by the Owner, all work as shown on Drawings and as specified hereinafter.

B. The piping systems and equipment to be insulated shall include, but not be limited to the following:
   1. Domestic hot, hot return and cold water piping.
   2. Horizontal storm drainage piping as indicated.

PART 2 - PRODUCTS

2.01 INSULATING MATERIALS

A. All insulation shall have a composite (insulation, jacket facing and adhesive used to adhere jacket or facing to the insulation) fire and smoke hazard ratings as tested by Procedure ASTM E-84, NFPA 255 and UL 73, not exceeding flame spread of 25, fuel contributed of 50, and smoke developed of 50. Accessories such as adhesives, mastics, cements, tapes and cloths for fittings shall have component ratings as listed above. Insulation shall be glass fiber with a maximum K factor 0.23 at 75°F mean temperature. Density shall not be not less than 3 lbs. per cu. ft.

B. The materials as specified below have been selected from the catalog of Owens-Corning Fiberglass Corp. and are representative of the quality, design and finish desired. Insulation as manufactured by other manufacturers may be submitted for approval, provided the products meet fully in all respects (such as density, moisture absorption, alkalinity, thermal-conductivity, jacket, etc.) the materials as designated below.
   1. Fiberglass Pipe Insulation: ASJ/SSL-II. Molded fibrous glass pipe insulation shall comply with the requirements of ASTM C.547.
      a. Provide Class 12 for hot and cold water plumbing piping.
   2. Fiberglass Pipe Fitting Insulation: FS HH-I-558, Form E, Class as indicated.
      a. Provide Class 16 for use with Class 12 pipe insulation, where temperature does not exceed 450°F.
3. Vapor Barrier Materials: ASTM 1136, Type I, paper-backed aluminum foil, except as otherwise indicated, strength and permeability rating equivalent to adjoining pipe insulation jacketing.

4. Bends shall be 0.016 inch thick, ¼" aluminum spaced 18" on center, by Insulation Industries, Inc.

5. Wires shall be 20 gage galvanized annealed steel, sealer shall be layer of J-M Duramesh 207 or equal.

6. Adhesives and Protection Finish shall be Benjamin Foster 30-36.

7. Jacketing Material for Equipment Insulation: Provide pre-sized glass cloth or canvas material, not less than 7.8 ounces per square yard.


2.02 RELATED MATERIALS AND REQUIREMENTS

A. At pipe supports Insul-Shield pipe saddles and matching hanger shall be used. Joints of insulation abutting Insul-Shielding pipe saddles shall be butted with IC-405, and the joints firmly pressed together.

B. All concealed and exposed piping shall be provided with factory ASJ (Owens/Corning Fiberglass) secured in place with vapor barrier adhesive IC-225. Provide ½" aluminum bands spaced 18" on centers.

2.03 INSULATION REQUIREMENTS

A. Cold Water Piping
   1. Cold Water - all sizes - ½" insulation, A.S. jacket SSL II.
   2. Storm drainage piping and drain body - minimum ½" insulation, A.S. jacket SSL II.
   3. Frostproofed Piping - 3" insulation, dual temperature fire retardant jacket.

B. Hot Water Piping
   1. Hot Water Supply - ½" to 2" I.D. - 1" insulation, A.S. jacket SSL-II.
   2. Hot Water Supply - 2-½" and larger - 1-½" insulation.
   3. Hot Water Circulating - all sizes - 1" insulation, A.S. jacket ASJ/SSL II.

2.04 PIPING EXPOSED TO FREEZING

A. Insulation on any piping, fitting, flange and valve located in areas exposed to freezing (in unheated areas, at cooling towers and where noted on the Drawings as to provide "Frost Insulation") shall, in addition to above covering, be increased by one inch with the same finish as specified for the particular service when not subject to freezing. Insulation shall always be a minimum of 2½" inches in thickness.

B. Weatherproofing of Piping:
   1. Weatherproof all insulated outdoor piping.
   2. Where weatherproofing is required, in addition to insulation and finishes specified for frostproofing, cover with Tedlar Film Jackets as made by ALPHA Assoc, Inc. (Woodbridge N.J.).
3. Fittings insulation shall be heavily coated with weatherproof mastic. Embed into the wet coat a layer of open weave glass cloth and finish with a second coat of same mastic over entire surface.

4. In addition to insulation and finishes specified for frostproof, cover with crimped aluminum sheet 0.016 inch thick with lock seams at longitudinal seams, and preformed straps at transverse joints. Joints and jacket shall provide complete weatherproof protection either by mechanical contact or by use of a permanent plastic weatherproof sealant.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage. Staples shall not be used on vapor barrier.

B. Cover valves, flanges, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory, precut or job fabricated units (at Installer's option) except where a specific form or type is indicated.

C. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.

D. Install protective metal shields and insulated inserts at each hanger and support to prevent compression of insulation.

E. Do not apply insulation to hot equipment.

F. Apply insulation using the staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.

G. Coat insulated surfaces of equipment with layer of insulating cement, troweled in a workmanlike manner, leaving a smooth continuous surface. Fill in scored block, seams, chopped edges and depressions, and cover wire netting and joints with cement of sufficient thickness to remove surface irregularities.

H. Cover insulated equipment surface with jacketing neatly fitted and firmly secured. Lap seams at least two inches. Apply over vapor barrier where applicable.

I. All horizontal storm drainage piping (except in service/utility corridor) under roofs, exposed and above hung ceiling, and roof drain bodies shall be insulated (sweat-proofing) as specified for water piping, but nested larger diameter covering over hubs and drain bodies.

J. Direct contact between pipe and hanger shall be avoided. Hanger shall pass outside of metal saddle which cover a section of high density insulation (such as calcium silicate) of sufficient length to support pipe without crushing insulation. Hangers or saddles shall not pierce insulation and vapor barriers.
3.02 INSTALLATION REQUIREMENTS

A. Install insulation products in accordance with the manufacturer's written instructions, and in accordance with recognized industry practices to ensure that the insulation serves its intended purpose.

B. Install insulation on pipe systems subsequent to testing and acceptance of tests.

C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete the run. Do not use cut pieces of scraps abutting each other.

D. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

E. The Contractor shall take every precaution necessary to ensure that the covering material is in satisfactory condition to receive painting.

F. Penetration of walls and floors by piping connection to rotating equipment shall be provided with a fiberglass sleeve, the full depth of pipe penetration.

G. In all cases where new piping connects to existing piping that is insulated, the existing insulation that is removed to make the new connection shall be replaced with new insulation as hereinafter specified.

H. Do not insulate hand holes, cleanouts, ASME stamp, or the manufacturer's nameplate. Provide neatly beveled edge at interruptions of insulation.

I. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

J. The installer of the piping insulation shall advise this Contractor of required protection for the insulation work during the remainder of the construction period, to avoid damage and deterioration.

END OF SECTION 22 07 00
SECTION 22 08 00
TESTING AND ADJUSTMENTS FOR PLUMBING WORK

PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section is coordinated with and complementary to the General Conditions and Special Conditions of the Work, wherever applicable to Plumbing Work.

B. Section 01 31 46 - Special Requirements for Mechanical Work shall apply.

C. Section 22 05 02 - General Provisions for Plumbing Work shall apply.

1.02 SCOPE OF WORK

A. The Work of this Contract includes providing all labor, materials, accessories, services to provide all necessary tests and adjustments of all plumbing and fire standpipe systems and make ready for operation by the Owner, all work as shown on the Drawings and as specified hereinafter.

1.03 REQUIREMENTS

A. The persons providing the specified work and their supervisors shall be personally experienced in the work; and shall have been regularly employed by a firm engaged in the installation of similar work for this project in scope for a minimum of five (5) years.

B. All tests shall be made in the presence of the Architect or his representatives, and the local authorities having jurisdiction of the work to be tested, as may be directed; and at least 72 hours notice shall be given in advance of all tests.

C. The Work of this Contractor shall include the furnishing of all labor and testing instruments, gauges, pumps, smoke machines, and other equipment required or necessary for tests, required by laws, rules and regulations and as specified.

D. Provide all other tests required by local inspectors and all other authorities having jurisdiction.

E. All appurtenances shall be operated after installation to determine whether or not they meet the requirements of the Specifications.

F. All defects disclosed in the work by tests and otherwise shall be made good or the Work replaced without additional cost to the Owner. No caulking on screwed joints, cracks or holes will be acceptable.

G. Tests shall be repeated after any defects disclosed thereby have been made good or the work replaced if it is deemed necessary.

H. All tests shall be made at the expense of the Contractor.
I. Tests are not permitted to be made with air except as noted.

J. It shall be the responsibility of the Contractor to keep records on all testing of systems.

K. Contractor to provide required test plug tee fittings during erection of pipe system.

L. If the pipe installation fails to meet testing requirements, the Contractor shall determine at his own expense the source or sources of leakage, and he shall repair or replace all defective materials or workmanship. The completed pipe installation shall meet the requirements of the tests after the leaks have been corrected.

M. All piping which is to be enclosed in partitions or hung ceilings shall be tested and made tight when directed by the Construction Supervisor and in adequate time to permit the installation of partitions and ceilings. When necessary, the Contractor shall drain the piping and/or take over such precautions as required to prevent damage by freezing.

N. The Contractor shall also be responsible for the Work of other trades that may be damaged or disturbed by the tests, or the repair or replacement of his Work, and he shall, without extra charges, restore to its original condition any Work so damaged or disturbed.

O. The testing procedures listed are the minimum required. Any jurisdictional codes that call for additional requirements shall naturally be done.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 INTERIOR PLUMBING SYSTEMS

A. All plumbing systems shall be tested in accordance with NYC code as described below.

B. Rough Piping Installations:
   1. Building drains, drainage and vent piping, except exposed short fixture connecting drain pipes, shall be tested and proven watertight upon completion of the rough piping installation prior to covering or concealment.
   2. Where the developed length of continuous drainage and vent pipe installation is less than 10 feet, a water flow test shall be applied to the drainage piping. Water flow through the drainage piping shall be provided at rates similar to the service conditions under which the piping is to function. This test method may be applied in testing existing buried building drains when permission is granted by the enforcement officer.
   3. Where the developed length of continuous drainage and vent pipe installation is 10' or more, a water pressure test shall be applied to the drainage and vent piping. Test pressure shall be equal to at least a 10' column of water at all points, except that the uppermost 10' of the system, measured downward from the highest roof vent terminal, need be subjected only to the pressure produced when water overflows from that terminal. The piping may be tested in sections when approved test fittings are provided at appropriate locations. Test pressure at any point in the system shall not be allowed to exceed the
equivalent of a 100' column of water. This test shall be applied to all building drains except those for which a water flow test is specially permitted.

4. An air pressure test, at five pounds per square inch gauge pressure, may be applied instead of the water pressure test when special permission is granted by the enforcement officer.

C. Completed Sanitary Drainage and Vent Systems:
1. Sanitary drainage and vent systems, upon completion, shall be tested and proven gastight.
2. After all plumbing fixtures have been installed and all traps have been filled with water, every part of new sanitary drainage and vent systems within building walls shall be subjected to a final test as prescribed herein. For the duration of testing, flow of water in the system shall be halted and the building drain shall be sealed adjacent to its point of entry inside the building. The enforcement officer may require the removal of any cleanout plugs to ascertain that the testing is effective in all parts of the system. Whenever there is reason to believe that the sanitary drainage or vent system of an existing building has become defective, a final test as prescribed herein shall be applied when deemed necessary by the enforcement officer.
3. A smoke pressure test shall be applied to the system by introducing into its lowest part a pungent, thick smoke produced by one or more approved smoke machines. As smoke belches from all roof vent terminals, they shall be sealed. Then the system shall be subjected to smoke pressure, equivalent to a 1" column of water, for the duration of testing.
4. A peppermint vapor test may be applied instead of a smoke pressure test when special permission is granted by the enforcement officer. The peppermint vapor shall be applied to the system by introducing into the roof vent terminal of every line or stack under test, at least two ounces of oil of peppermint, followed immediately the introduction of 10 quarts of boiling water. Then, the roof vent terminals shall be promptly sealed for the duration of testing. The presence of oil of peppermint or persons in contact with such vapor shall be excluded from the test area inside the building.

3.02 DOMESTIC WATER

A. The water supply systems shall be tested to a hydraulic pressure equal to 1½ times the normal operating pressure before being enclosed and before non-conducting covering is applied. All leaks or defects indicated by tests shall be repaired or replaced with new material. Run test without a loss of pressure for a minimum of two hours. Contractor shall verify each system test pressure prior to testing system.

B. All equipment shall be tested and adjusted where required to assure proper operation.

3.03 NATURAL GAS SYSTEM

A. Test in accordance with State and Local Standards and NFPA.

B. Distribution pressures up to and including ½ psig: The completed piping is to be tested (at 3 psig) with a mercury gauge at a pressure equal to a column of mercury 6” in height for a minimum of one hour.
C. Distribution pressures over ½ psig through 3 psig: The completed piping is to be tested at 50 psig for a minimum of one hour.

3.04 DOMESTIC HOT WATER CIRCULATING PIPING

A. Contractor shall balance the domestic hot water systems circulation piping and maintain all records (i.e., time, date, setting, flow, etc.) for turnover to Owner with operation manual.

END OF SECTION 22 08 00
PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section is coordinated with and complementary to the General Conditions and Special Conditions of the Work wherever applicable to Mechanical and Electrical Work.

B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

C. Section 22 05 02 - General Provisions for Plumbing Work shall apply.

1.02 SCOPE OF WORK

A. The work of this Contract includes the providing of all labor, materials, accessories, services and tests necessary to install, complete and make ready for operation by the Owner, all work as shown on the Drawings and as specified herein.

1.03 SPECIFIC REQUIREMENTS

A. Pipe and fittings shall conform to the latest USASI, ASTM, ANSI and/or F.S. Standards, and/or Cast Iron Soil Pipe Institute Standards No. 301 and 310.

B. All pipes, fittings, traps, materials and/or other devices used in the plumbing system shall have cast, stamped, or indelibly marked on it the maker's name or mark, weight, and quality of the product when such marking is required by the approved standard.

PART 2 - PRODUCTS

2.01 INTERIOR PIPING

A. Interior above-ground domestic water piping shall be seamless drawn or extruded hard temper Type "L" copper tubing, ASTM B-88, with wrought copper solder joint fittings suitable for brazing and shall conform to ANSI B16.22 solder joint fittings. Joints shall be made with a solder alloy (95/5) consisting of tin-antimony and shall conform to ASTM Specification B-32.

1. Subject to approval, the Contractor has the option of using grooved end piping and grooved end fittings with mechanical type couplings for sizes 2” and larger for domestic water piping systems. The Contractor shall state the materials in his bid that he intends to provide.

a. Grooved fittings shall be wrought copper per ASTM B75 or B152 and ANSI B16.22, or bronze sand casting per ASTM B584-87 copper alloy CDA 836 per ANSI B16.18. Fittings shall be copper tubing sized. (Flaring of pipe ends to IPS dimensions will not be permitted.

b. Grooved couplings shall be ASTM A395 and A536 ductile iron, coated with copper colored alkyd enamel. Coupling housings shall be angle-pattern bolt pad type to
provide system rigidity. Couplings shall be copper tubing sized. Coupling gaskets shall be grade EPDM, UL classified in accordance with ANSI/NSF 61 for potable water service.

B. Interior above ground soil waste and vent piping shall be no-hub cast iron soil and fittings with stainless steel couplings similar to Clamp-All. No-hub piping shall be installed with all supports and sway bracing as specified in Section 22 10 03 – Hangers and Supports.

C. Medical Gas Piping:
   1. All pressurized medical gas piping shall be;
      a. Seamless ASTM B-819, type K for underground and type K or L hard drawn seamless medical gas copper tubing for above ground. They shall be identified by the markings "OXY" "MED" "OXY/MED" "OXY/ACR" , or "ACR/MED" in green (Type K) or blue (Type L).
      b. Fittings shall be wrought copper, brass or bronze designed expressly for brazed connection.
      c. Pipe (Tube), fittings, valves, and other components shall be specially cleaned for oxygen service in a facility equipped to clean, rinse, and purge the material in accordance with the requirements of NFPA-99 5.1.10.1.1 and received on job site cleaned and capped. On site cleaning of the interior surfaces of tubes, valves, fittings, and other components is not allowed.
      d. Brazing alloy shall be BCuP-5 Brazing alloy or equivalent alloy with at least 1000 degree F melting point.
   2. All vacuum and WAGD tubing 3 inch and smaller shall be:
      a. Type “L” or “M”, ASTM B-280 ACR copper.
      b. Brazed with BCuP-5 Brazing alloy or equivalent alloy with at least 1000 degree F melting point.
   3. Isolation of copper tubing from dissimilar metal shall be accomplished either through use of copper or copper plated hangers or hangers with plastic isolators.

PART 3 - EXECUTION

3.01 INSTALLATION NOTES FOR INTERIOR PIPING

A. It is the intent that each part of the plumbing systems shall be complete in all details and all lines provided with all control valves as indicated on Drawings, or as may be required for the proper control of the pipe lines under this Section so that any fixture, line or piece of apparatus may be cut out for repair without interference or interruption of the service to the rest of the building.

B. The size of storm, soil, waste, water, and vent piping shall be as determined by the local rules and regulations for plumbing and drainage, except where specifically noted to be larger by the Specifications or plans; and all fixed rules of installation as set forth in the Rules and Regulations shall be followed as part of the Specifications.

C. The Contractor shall examine carefully the architectural plans and details and familiarize himself with all conditions relative to the installation of piping, particularly where same is concealed behind furring or in hung ceilings.
D. In no case shall the Contractor permit his pipes to be exposed beyond finished plaster lines unless specifically shown on Drawings. He shall consult with the other trades in the building and install his piping in such a way as to least interfere with the installation of other trades.

E. Water piping shall be installed to drain, and branches shall not be trapped, but shall have continuous pitch. Where necessary to raise or lower mains, the same shall be provided with a drip and shall be properly valved and capped.

F. Piping shall be installed, whether indicated or not, so as to rise and/or drop to clear any and all conduits, lighting fixtures, ductwork and heating mains, in order to maintain the desired clear heights. The Contractor shall consult with the other trades and facilitate the erection of the equipment and piping.

G. Run piping straight and as direct as possible. In general, form right angles with or parallel to walls or other piping. Risers shall be erected plumb and true.

H. After cutting, all pipes shall be reamed out to full bore and before erection the inside of all pipes shall be thoroughly cleaned.

I. No piping or work shall be concealed or insulated until all required tests have been satisfactorily completed and work has been approved by the Architect and all other authorities having jurisdiction.

J. Branch connections of the drainage systems shall be made with "Wye" and long "Tee-Wye" fittings. Short ¼" bends, common offsets and double hubs will not be permitted. Short "Tee-Wye" fittings are to be used in a vertical position only.

K. Cleanouts shall be provided at the base of all stacks, all changes of directions, at the ends of branch runs where shown, every 50'-0" and as required by Code, and shall be furnished as described under cleanouts.

L. The house drains must be run at a minimum grade of ½" per foot downward in the direction of flow. Wherever possible, a ¼" per foot pitch shall be maintained. Branch connections to stacks from fixtures shall pitch ¼" per foot where possible. Attention is again called to the necessity of maintaining the ceiling heights established.

M. Connection to roof drains shall be installed in conjunction with the roofing called for under another Division or Section of these Specifications and at such times as designated by this Contractor, so that the building is adequately protected during construction from damage by storm water. All piping shall be adequately and properly supported, and all joints shall be made up as hereinafter specified.

N. Furnish and install complete systems of ventilating pipes from the various plumbing fixtures and other equipment to which drainage connections are made. Ventilating pipes shall be connected within 2'-0" of the discharge of each trap and shall be individually piped to point above the ultimate overflow level of the fixture before connecting with any other vent pipe (in general, this will be approximately 3'-6" above the finished floor). Branches shall be arranged to pitch back to fixtures.
O. The individual vent pipes shall be collected together in branch vent lines and connected to vent stacks. Wherever possible, vent stack offsets shall be made with 45 degree fittings. The heels of vent stacks shall be connected to adjacent soil stacks for purpose of draining condensation where possible. The waste of one fixture shall be connected to the base of each vent stack for the purpose of washing out any scales or dirt which may accumulate, or the soil stack shall be used to wash out the heel of the vent.

P. The tops of all soil and waste stacks shall be extended as additional ventilating pipes. The tops of all ventilating stacks shall run independently through the roof. Pipes smaller than 4" size shall be increased to 4" by means of approved increasers before passing through the roof slab.

Q. Expansion loops and anchors shall be provided on all hot water and hot water circulation mains. Expansion loops shall be made with four elbows and three lengths of pipe, except as otherwise noted on the Drawings. All loops shall be prestressed.

R. All piping installed in finished areas shall be completely concealed within hung ceilings, furrings, soffits, pipe spaces, etc.

S. Where complete concealment is impossible because of obstructions such as beams, ducts, lights, piping, etc., the Contractor shall not install any work before first consulting with the Architect and his instructions (written or revised Drawings) shall be followed.

T. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.

3.02 NO-HUB PIPING - ADDITIONAL REQUIREMENTS

A. Pipe hanger shall be provided at each coupling for horizontal piping.

B. Stacks shall be supported at their bases and at each floor, by floor clamps.

C. Horizontal piping 5" and larger shall be braced at each branch and at every change in direction (including 3" and 4" branch piping at each change of direction).

D. Sway bracing shall be provided on horizontal piping that is suspended in excess of 18" below slab, at 30' intervals.

E. Horizontal storm drainage piping 5" and larger shall be braced at every coupling.

3.03 DISINFECTION

A. The entire domestic water piping system shall be thoroughly disinfected with chlorine before acceptance for domestic operation, in strict accordance with the code.

B. The amount of chlorine applied shall be such as to provide a dosage of not less than 50 parts per million. The chlorinating material shall be either liquid chlorine or sodium hypochlorite solution and shall be introduced into the system and drawn to all points of the system. All lines shall be thoroughly flushed before introduction of the chlorinating material. After a contact period of not less than eight (8) hours, the system shall be flushed with clean water until the residual content is
not greater than 0.2 parts per million. All valves in the lines being sterilized shall be opened and closed several times during the contact period.

C. Sterilization and tests for purity of water in the entire piping system shall be performed by the Contractor through an approved independent testing laboratory and a certificate shall be furnished to the Resident Engineer certifying the quality of purity.

END OF SECTION 22 10 01
PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section is coordinated with and complementary to the General Conditions and Special Conditions of the Work wherever applicable to Mechanical and Electrical Work.

B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

C. Section 22 05 02 - General Provisions for Plumbing Work shall apply.

1.02 SCOPE OF WORK

A. The Work of this Contract includes providing all labor, materials, accessories, services and tests necessary to install complete and make ready for operation by the Owner, all work as shown on Drawings and as specified hereinafter.

1.03 SPECIAL REQUIREMENTS

A. Furnish all valves as indicated on the plans, or as may be required for the proper control of the pipe lines installed under these Specifications, so that any fixture, line or piece of apparatus may be cut out for repair without interference or interruption of the service to the rest of the building. All water valves shall have a minimum working pressure of 125 psi, and shall be water rated unless otherwise noted on the Drawings or specified herein. All valves shall be of one manufacturer.

B. All gate valves within the building shall be wedge gate valves with painted iron wheel handles. They shall have gland followers in stuffing boxes, and shall be constructed so that they may be repacked while open and under pressure. All valves shall have the name of the manufacturer and working pressure cast or stamped on them.

C. All gate valves 3" and smaller shall be all bronze with brazed or screwed joint ends as required by the piping system in which they are installed.

D. All gate valves 4" and larger shall have iron bodies with bronze mounting except where otherwise required by the authorities having jurisdiction and shall be provided with screwed or flanged ends as required by the piping system in which they are installed. All gate valves controlling equipment shall be of the OS&Y rising stem type except where space conditions do not permit the installation of this type of valve. In such cases non-rising stem valves shall be provided.

E. Globe valves shall be of all bronze with composition disc, threaded or brazed joint ends as required by piping system in which they are installed.

F. Check valves up to and including 3" shall be all bronze swing check type with threaded or brazed joint ends. Check valves 4" and larger shall have bronze mounted iron bodies and shall be
provided with screwed or flanged joint ends as required by piping system in which they are installed.

G. Drain valves shall be ¾" heavy cast brass with composition washers with male thread for hose connections.

H. At the high point of the hot water piping system provide a ½" automatic IBBM air relief valve, 125 PSI, WOG Class. Pipe drain to spill over adjacent floor drain or service sink.

I. All valves on the exterior domestic and fire protection water piping shall comply with local Fire Department and Water Company regulations.

J. All valves shall have the trademark of the manufacturer and the guaranteed working pressure cast or stamped on the body of the valve. All gates or globes, etc., shall be of one manufacturer.

K. All valves used on the fire standpipe systems shall be approved by the Underwriters' Laboratories and all other authorities having jurisdiction. Valves shall be bronze mounted iron bodies OS&Y solid wedge type valves with rising stems for 175 psi minimum working pressures; iron wheel handles shall be painted red. Tamper switches shall be provided on all fire standpipe valves as indicated on the Drawings.

L. The exterior valves shall conform to all applicable requirements of American Water Works Association C500-61 Standard for Gate Valves for Fire Water Work Service.

PART 2 - PRODUCTS

2.01 INTERIOR PIPING SYSTEM VALVES

A. Domestic water valves tabulated herein have been selected from the catalog of the Milwaukee Valve Co. Approved equals of Jenkins Co., Crane Co. and Walworth Co. will be reviewed.

<table>
<thead>
<tr>
<th>Gate Valve Bronze</th>
<th>3” and smaller</th>
<th>Solder end/non-rising</th>
<th>115</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Threaded/non-rising</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solder end/rising stem</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Threaded/rising stem</td>
<td>148</td>
</tr>
<tr>
<td>Gate Valve Iron</td>
<td>4” and larger</td>
<td>Flanged/rising stem</td>
<td>F2885A</td>
</tr>
<tr>
<td></td>
<td>4” and larger</td>
<td>Flanged/non-rising</td>
<td>F2882A</td>
</tr>
<tr>
<td>Globe Valve Bronze</td>
<td>3” and smaller</td>
<td>Threaded</td>
<td>502</td>
</tr>
<tr>
<td></td>
<td>3” and smaller</td>
<td>Soldered ends</td>
<td>1502</td>
</tr>
<tr>
<td>Globe Valve Iron</td>
<td>4” and larger</td>
<td>Flanged</td>
<td>F-2981A</td>
</tr>
<tr>
<td>Angle Valve Bronze</td>
<td>3” and smaller</td>
<td>Threaded</td>
<td>504</td>
</tr>
<tr>
<td>Check Valve Bronze</td>
<td>3” and smaller</td>
<td>Threaded</td>
<td>509T</td>
</tr>
<tr>
<td>Check Valve Iron</td>
<td>4” and larger</td>
<td>Flanged</td>
<td>F2974A</td>
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<tr>
<td>Ball Valves</td>
<td>2” and smaller</td>
<td>Threaded</td>
<td>BA-100/BA-150</td>
</tr>
<tr>
<td></td>
<td>2” and smaller</td>
<td>Soldered ends</td>
<td>BA-100/BA-150</td>
</tr>
</tbody>
</table>

B. Drain valves shall be similar to Milwaukee Co. Model № BA-100H/BA-150H or equal.
2.02 LOCAL EQUIPMENT AND FIXTURE PRESSURE REGULATORS

A. Furnish and install a CASH-ACME type HR Series or approved equal water pressure reducing valve on all cold and hot water branch lines for laboratory equipment as provided under other Divisions or Sections of these Specifications. Pressure reducing valves shall be of the differential type, self-contained, single seated, direct acting, spring locked type with no diaphragm. Valve body and spring housing shall be bronze and all other parts shall have a corrosion resistance equal to bronze.

B. All valves shall be sealed against leakage including a top cap over the adjusting screw.

C. Internal parts subject to wear shall be replaceable without removing valve from the pipe line, and valve shall be provided with means to adjust outlet pressure setting.

D. Valves shall have sufficient water capacities to provide required rates of flow and shall be set at discharge pressure as required by the points of use.

PART 3 - EXECUTION

3.01 INSTALLATION REQUIREMENTS

A. The entire plumbing and fire protection systems shall be supplied with valves so located, arranged and operated as to give a complete regulating control to all fixtures and apparatus.

B. Shut-off valves shall be provided on all risers, branch lines and at each piece of equipment.

C. Install check and globe valves on downstream side of the shut-off valve on hot water circulating riser and branch lines.

D. Valves, where exposed and used in connection with finished piping, shall have the same finish as the pipe.

E. Provide drain valves at the heel of each plumbing water riser and at low points of the horizontal mains.

F. Provide chain operators on all valves 4" and larger located 7'-0" and higher above floor.

G. Provide shut-off valves and check valves on each pump discharge line.

H. All valves used on branch piping to bathroom and kitchens shall be all union style ball valves suitable for service to which they are connected.

I. Install valves where required for proper operation of piping and equipment, including valves in branch lines necessary to isolate sections of piping. Locate valves so as to be accessible.

J. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward.
K. Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

L. Install valves with bodies of metal other than cast iron where thermal or mechanical shock is indicated or can be expected to occur.

M. Do not install bronze valves and valve components in direct contact with steel, unless bronze and steel are separated by dielectric insulator.

N. Select and install valves with outside screw and yoke stems, except provide inside screw non-rising stem valves where headroom prevents full opening of OS&Y valves.

O. Except as otherwise indicated, install gate, ball, and globe valves to comply with ANSI B31.1. Where throttling is indicated or recognized as principal reason for valve, install globe or ball valves.

P. Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign material in piping system can be expected to prevent tight shut-off of metal seated valves.

Q. Select and install valves with replaceable seats, except where otherwise indicated.

R. Installation of Check Valves
   1. Swing Check Valves: Install in horizontal position with hinge pin located on the upside of the pipe and perpendicular to the pipe's centerline.
   2. Wafer Check Valves: Install between 2 flanges in horizontal or vertical position.
   3. Horizontal Lift Check Valve: Install in horizontal pipe section with stem vertically upward.
   4. Vertical Lift Check Valve: Install in vertical pipe section with upward flow.
   5. Spring Loaded Horizontal Lift Check Valve: Install in horizontal pipe line with stem vertically upward.

END OF SECTION 22 10 02
PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section is coordinate with and complementary to the General Conditions and Special Conditions of the Work wherever applicable to Mechanical and Electrical Work.

B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

C. Section 22 05 02 - General Provisions for Plumbing Work shall apply.

D. Section 23 20 00 – Piping for HVAC shall apply.

1.02 SCOPE OF WORK

A. The work of this Contract includes providing all labor, materials, accessories, services and tests necessary to install complete and make ready for operation by the Owner, all Hangers and Supports for Plumbing and Fire Protection Systems as shown on the Drawings and as specified hereinafter.

1.03 SPECIFIC REQUIREMENTS

A. Provide products which are Underwriters Laboratories listed and Factory Mutual approved.

B. Provide pipe hangers and supports of which materials, design, and manufacture comply with ANSI/MSS SP-58.

C. Select and apply pipe hangers and supports, complying with MSS SP-69.

D. Fabricate and install pipe hangers and supports complying with MSS SP-89.

E. Assume the responsibility for the proper transfer of the loads of the piping system to the structure. No additional cost to the Owner should be expected for any corrective work during construction.

F. Supports and hangers shall be provided for all horizontal and vertical piping. The hanger design shall conform to the ASA Code for Pressure Piping. Hangers shall be kept outside of pipe insulation.

G. All bracket clamps and rod sizes indicated in these Specifications are minimum size only. This Contractor shall be responsible for structural integrity of all supports. All structural hanging material shall have a safety factor of five (5) built in.

H. All horizontal cast iron pipe shall be supported every five (5) feet and at each hub and/or "no-hub" clamping assembly. When a concentration of fittings occur, additional support shall be installed.
consistent with good trade practices. "No-hub" system must be supported in accordance with Standard CISPI-310-78.

I. All hangers and supports for fire standpipe and sprinkler systems shall be Underwriters Laboratories approved. Fire standpipe and sprinkler piping shall be independently supported.

PART 2 - PRODUCTS

2.01 HANGERS AND SUPPORTS

A. Pipe supports shall be of the following type and figure number, manufactured by C&P, B-Line, Grinnell, or equal as approved:

B.  

<table>
<thead>
<tr>
<th>Description</th>
<th>Carpenter &amp; Patterson (Witch)</th>
<th>Grinnel (Anvil)</th>
<th>B-Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-clamp with retaining clip and locknut (pipe sizes 2&quot; and smaller)</td>
<td>47 with 22</td>
<td>86 with 89</td>
<td>B3036</td>
</tr>
<tr>
<td>Beam Clamp</td>
<td>293</td>
<td>228</td>
<td>B3291</td>
</tr>
<tr>
<td>Multi-J Hook</td>
<td>228</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J-Hook</td>
<td>221</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clevis Hanger</td>
<td>100</td>
<td>260</td>
<td>B3100</td>
</tr>
<tr>
<td>Clevis Hanger w/Saddle</td>
<td>100SH</td>
<td>100SH</td>
<td></td>
</tr>
<tr>
<td>180° Shield</td>
<td>265P</td>
<td>168</td>
<td>B3153</td>
</tr>
<tr>
<td>Single Rod Roll Hanger</td>
<td>140</td>
<td>181</td>
<td>B3110</td>
</tr>
<tr>
<td>Double Rod Roll Hanger</td>
<td>142</td>
<td>171</td>
<td>B3114</td>
</tr>
<tr>
<td>Trapeze</td>
<td>46</td>
<td>1600-1700</td>
<td></td>
</tr>
<tr>
<td>U-Bolt Adjustable Pipe</td>
<td>283</td>
<td>137C</td>
<td>B3188C</td>
</tr>
<tr>
<td>Stanchion Saddle</td>
<td>247</td>
<td>259</td>
<td>B3090</td>
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<tr>
<td>Welded Steel Bracket</td>
<td>84 or 139</td>
<td>199</td>
<td>B3067</td>
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<tr>
<td>Riser Clamp</td>
<td>126</td>
<td>261</td>
<td>B3373</td>
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<tr>
<td>Welded Beam Attachment</td>
<td>113A</td>
<td>66</td>
<td>B3083</td>
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<tr>
<td>Welded Beam Attachment w/Bolt and Nut</td>
<td>113B</td>
<td>66</td>
<td>B3083</td>
</tr>
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<td>Concrete Insert</td>
<td>108</td>
<td>282</td>
<td>B3014</td>
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<tr>
<td>Phillips Inserts</td>
<td>513</td>
<td>Phillips Insert</td>
<td></td>
</tr>
</tbody>
</table>

C. Insulation Protection
   1. For all insulated pipe furnish clevis hangers with welded shields and equal to B-Line Fig. B3100 w/B3151.

D. Pipe Supports in Pipe Chases
   1. Supports shall securely hold piping, prevent vibration, etc. Provide pipe supports and channels as required. Use Grade KIA Cycolac DH self-extinguishing ABS as manufactured by the Sumner Corporation or approved equal.
PART 3 - EXECUTION

3.01 INSTALLATION REQUIREMENTS

A. Provide necessary structural members, hangers and supports of approved design to keep piping in proper alignment and prevent transmission of injurious thrusts and vibrations. In all cases where hangers, brackets, etc., are supported from concrete construction, care shall be taken not to weaken concrete or penetrate waterproofing. All hangers and supports shall be capable of screw adjustment after piping is erected. Hangers supporting piping expanding into loops, bends and offsets shall be secured to the building structure in such a manner that horizontal adjustment perpendicular to the run of piping supported may be made to accommodate displacement due to expansion. All such hangers shall be finally adjusted, both in the vertical and horizontal direction. Hangers in contact with copper or brass pipe shall be copper plated steel.

B. Pipe hangers shall be of the clevis and pipe roller types, except where otherwise noted.

C. Where piping is run near the floor and not hung from the ceiling construction but is supported from the floor, such supports shall be of pipe standards with base flange and adjustable top yoke similar to B-Line Fig. B3093 (C&P Fig. 101) or equal.

D. Except where otherwise noted, piping shall be supported from structural steel only. Provide supplementary steel where required.

E. Piping shall not be hung from other piping, ducts, conduits or from equipment of other trades.

F. All water piping connected to rotating equipment within all mechanical spaces shall be isolated from the building structure by means of vibration hangers inserted in the hanger rods. The vibration hangers shall consist of a steel spring in combination with a double deflection neoprene element within a rectangular steel housing. Combined static deflection shall be 1.375" minimum. Hangers shall have capability of supporting the piping at a fixed elevation during installation and shall incorporate an adjusting device to transfer the load to the spring. Deflection shall be indicated by means of scale. Vibration hangers shall be Fig. No. 360 or Vibratol type HESL (Options 2 and 4) as made by B-Line Systems, as specified under another Section of these Specifications.

G. Where additional steel is required for the support of hangers, furnish and install same subject to the approval of the Architect. Piping shall not be supported from the metal deck slab construction.

H. All piping running on walls shall be supported by means of hanger suspended from heavy angle iron wall brackets. No wall hooks will be permitted.

I. Lateral bracing of horizontal pipe shall be provided where required to prevent side sway or vibration. The lateral bracing shall be of a type approved by the Architect and shall be installed where directed by the Architect.

J. All anchors shall be separate and independent of all hangers, guides and supports. Anchors shall be of heavy blacksmith construction suitable in every way for the work approved by the
Architect. Anchors shall be welded to the pipe and fastened to the structure with anchor type bolts.

K. Anchors shall be fabricated and assembled in such a form as to secure the piping in a fixed position. They shall permit the line to take up its expansion and contraction freely in opposite directions away from the anchored points; and shall be so arranged as to be structurally suitable for particular location and line loading. Submit details for approval.

L. All horizontal steel and copper pipe shall be supported at maximum intervals as follows: Steel pipe - up to 1¼" - 8'-0"; 1½" to 2½" - 10'-0"; 3" and larger - 12'-0". Copper tube and Brass Pipe - up to 1¼" - 6'-0"; 1½" to 2½" - 8'-0"; 3" and larger - 10'-0". There shall be no metal-to-metal contact at supports for non-ferrous pipes. Provide ⅛" thick lead strips or Summer Inc. pipe clamps under uninsulated piping at supports. Hangers and supports shall be installed outside of insulation or insulated piping.

M. Trapeze type hangers shall be made up of angles bolted back-to-back or channels for supporting parallel lines of piping. Trapeze type hangers shall be supported with suspension rods having double nuts, and securely attached to construction with inserts, beam clamps, steel fishplates, cantilever brackets, lag screws or other approved means. Use approved type brackets for supporting piping attached along walls. Non-insulated piping (compressed air, gas, etc.) supported by trapeze hangers shall be provided with hold down clamps at the trapeze hangers. If only non-ferrous piping (copper, etc.) is supported on the trapeze hangers, the trapeze and hold down clamps shall be epoxy painted.

N. Maximum weights on hanger rods shall be such that stress in tension shall not exceed 9,000 psi, using root area of threaded portion. In no case shall hanger sizes be less than ⅛" for pipe up to 2", ½" for pipe 1½" to 3½", ⅝" for pipe 4" to 5", ¾" for pipe 6", ⅞" for pipe 8" to 12".

O. Supports for vertical piping shall be double bolt riser clamps, with each end having equal bearing on the building structure located at alternate floors. Cast iron soil pipe shall be supported at every floor and at its base.

P. All auxiliary steel for pipe supports shall be furnished and installed under this Section.

Q. All hangers, rods, inserts, clamps, stanchions, brackets, etc., shall be dipped in zinc chromate primer before installation and provided with one (1) coat of approved type paint after installation. (Refer to Section 01 31 46.)

R. Chains, straps, perforated iron or wire hangers are not permitted.

S. The Architect must approve method of supporting pipes from building structure before work is started. The Contractor shall bear all responsibility for materials and workmanship as described in this Section, and shall make sure that all hangers and supports are properly and permanently connected to building structure. No piping shall be hung from metal deck; auxiliary steel shall be provided.

T. All pipe support shall be installed to avoid interference with other piping, hangers, electrical conduits and supports, building structures and equipment.
PART 1 - GENERAL
1.01 DESCRIPTION
   A. This Section is coordinate with and complementary to the General Conditions and Special Conditions of the Work, wherever applicable to Mechanical and Electrical Work.
   B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.
   C. Section 22 05 02 - General Provisions for Plumbing Work shall apply.

1.02 SCOPE OF WORK
   A. The Work of this Contract includes providing all labor, material, equipment, accessories, services, and tests necessary to complete and make ready for operation by the Owner, all work as shown on the Drawings and hereinafter specified.

PART 2 - PRODUCTS
2.01 ESCUTCHEONS
   A. This Contractor shall provide escutcheons on all exposed pipe wherever they pass through floors, ceilings, walls or partitions.
   B. Escutcheons for pipes passing through outside walls and floors shall be Ritter Pattern and Casting Co., No. 1, solid, cast brass, flat type secured to pipe with set screws.
   C. Escutcheons for pipes passing through interior walls, partitions, and ceilings shall be Ritter Pattern and Casting Co., No. 1, solid, cast brass chromium plated type, secured to pipe with set screws.
   D. Escutcheons for pipes in unfinished areas shall be cast iron, secured with set screws.

2.02 TRAPS
   A. Each fixture and piece of equipment requiring connection to the drainage system shall be separately trapped by means of a water seal trap placed as close to the fixture as possible.
   B. All running traps on drains, etc., shall have inlet handhole cleanouts and brass plug cleanouts in bottom. Cast iron traps below grade shall have bottom plug omitted. All exposed P traps shall have bottom cleanouts and shall be chromium plated brass.

2.03 DISSIMILAR METALS
   A. Connections between pipe, fittings, hangers and equipment of dissimilar metals shall be avoided.
B. Dielectric unions or insulated couplings shall be installed between copper or brass piping material and steel piping material or steel tanks. Unions or insulated couplings shall be used for pipe sizes 2" and smaller, and use dielectric gaskets on flanges and sleeves for pipes 2-1/2" and larger.

C. Pipes, fittings, hangers, etc., of dissimilar metals shall be insulated against direct contact with each other by using a high quality or grade of dielectric insulating material.

2.04 PIPE SLEEVES

A. Any pipe required in walls and floors shall be provided with a pipe sleeve.

B. Provide watertight sleeves for all pipes penetrating exterior foundation walls and waterproof floor areas and where other waterproof areas are noted on the Architectural and Structural Drawings.

C. Except where indicated or specified otherwise, provide and install Schedule 40 galvanized steel sleeves for all piping passing through concrete walls or floor slabs. Sleeves shall be securely set in the framework and where not specified otherwise shall be of such length as to extend flush with each face of the wall in which they are installed. Sleeves shall be securely set in floors 3" above unfinished floor and 2" above the finished floor or tile, as applicable. Sleeves in kitchen and laundry areas shall be chrome plated.

D. Sleeves shall have an internal diameter of at least 1" larger than the outside pipe size diameter of the pipe passing through them. Sleeves in exterior foundation walls shall be James B. Clow and Sons, No. F-1430 or F-1435, or approved equal, extra-heavy cast iron wall sleeves with intermediate integral flange. Cast iron sleeves shall be set with ends flush with wall faces.

E. Where sleeves penetrate waterproofing, install caulking between pipes and pipe sleeves as follows:
   1. Pack oakum to a depth of 1" between pipe and pipe sleeve at a location permitting 3" of sealant to be installed above the oakum.
   2. Fill space above oakum to a depth of 3" with sealant similar and equal to Igas Joint Sealer as manufactured by Silka Chemical Corporation.

F. Sleeves for gas piping shall extend 4 inches beyond exterior face of wall and 1 inch beyond inner face.

G. Sleeves in waterproof floors shall be as manufactured by Zurn Inc. or equal, cast iron sleeve with integrally cast flange and flashing device.

2.05 STACK SLEEVES

A. Stack sleeves for pipes passing through roof shall be equal to Zurn Z-195-10, with cast iron body, adjustable flashing ring, rust resistant bolts, and under deck clamp. The adjustable flashing ring shall be caulked after it is in the proper position. The space between the flashing sleeve and the pipe passing through same shall be caulked watertight.

2.06 UNIONS

A. Where Required
   1. On inlet and outlet of all apparatus and equipment having connections 2" and smaller. Where valves are adjacent to equipment, unions shall be on equipment side of valves.
B. Type
1. Steel piping: Malleable iron, WOG female pattern, brass seat, ground joint, 300 lb.
2. Copper tubing: Ground joint, cast iron, 150 lb. WOG pattern.
3. For piping over 2" flanged joints to be used.
4. Gaskets shall be 1/16" thick similar to Garlock or Cranite factory cut, one piece.

2.07 DRAINS

A. Drains shall have heavy cast iron, with double drainage flange and weep holes, with outlet connections as indicated and of sizes indicated on Drawings. Drains (except as noted) shall be furnished with high polished brass tops consisting of a one-piece rim secured to the body and vandal-proof spanner type screws, and a solid brass grate with reinforcing members on underside. Removable sediment basket shall be of heavy duty one-piece construction as specified hereinafter. All strainers or grates shall be secured with vandal-proof spanner type screws, unless otherwise specified.

B. All drains in floors with a waterproof membrane shall be equipped with 6 lb. lead flashing or 20 oz. soft rolled sheet copper and secured to the flashing flange with brass bolts and cast iron clamping device. Flashings shall bond not less than 1'-0" on all sides into membrane waterproofing.

C. On roofs furnish and set in conjunction with the roofer and when directed by the General Construction Contractor, approved roof drains of cast iron unless otherwise indicated.

D. Flashing of 6 lb. lead or 20 oz. soft rolled sheet copper, 34" x 34", shall be furnished and installed at each roof drain by means of non-puncturing type flashing clamping device.

E. Set all drains in such a way that the floor finish and top of the drain will be plumb and flush with finish floor without requirements for future additional extension, modifications, etc.

F. All drains, except as noted, shall be similar to or equal to Zurn Mfg. Co. and shall be as follows:
1. Floor Drains F.D. Type A (Mechanical and Concealed Equipment Rooms) - Similar and equal to No. Z-521Y cast iron body and flashing collar with cast iron tractor grate and flat bottom strainer. No. Z-414 cast iron funnel attached to grate, where indicated on the Drawings.
2. Floor Drains F.D. Type B (Toilet Rooms Finished Area, etc.) - Similar and equal to No. ZN-415-B-CP cast iron body, flashing collar, square nickel bronze top.

2.08 CLEANOUTS

A. Provide easily accessible cleanouts where indicated; at base of vertical stacks and leaders, at ends of horizontal drainage lines and at intervals not exceeding 50 ft., at each change of direction, on hand holes of running traps, and where indicated to make entire drainage system accessible for rodding. Provide at least 18 inch clearance to permit access to cleanout plugs.

B. Cleanouts for cast iron pipe shall consist of tapped extra heavy cast iron ferrule caulked into cast iron fittings, and extra heavy brass screw plug with solid hexagonal nut.

C. Cleanouts turning out through walls and up through floors shall be made by long sweep ells of "Y" and ½ bends with plugs and face or deck plates to conform to architectural finish in room. Where no definite finish is indicated on the Architectural and/or Mechanical Drawings, wall
plates shall be chrome plated cast brass and floor plates shall be nickel bronze. Screws in cleanouts in finished areas shall be vandal-proof.

D. Cleanouts shall be full size at the pipe up to and including 6 inch pipe. On larger size piping, 6 inch size plugs shall be used.

E. The following schedule indicates the various types of cleanouts desired at various locations indicated on the Drawings. These cleanouts have been selected from the catalog of Zurn and are representative of quality design and finish desired. Cleanouts of Josam Mfg. Co., or J.R. Smith may be submitted provided they meet Specifications fully in every respect (such as material, weight, clamping features, finish, etc.). The characteristics and quality of the cleanout shall be as follows.

1. Cleanout fitting in vertical stacks shall consist of tapped tees, capable of receiving a rough brass raised head cleanout plug; Zurn 1468.
2. Cleanouts in Mechanical Equipment Rooms shall be Zurn 1400.
3. Cleanouts in finished areas shall be Zurn Z-1420-3 or Z-1402TX with recess for tile floors.
4. Cleanouts in Dex-O-Tex waterproof floors shall be Zurn No. Z-1400 with extra heavy duty top.
5. Cleanouts for 3 or more fixtures piped horizontally shall be extended to wall cleanouts, and shall be Zurn No. Z-1470.
6. All cleanout plugs shall be brass and lubricated with graphite before installation.

PART 3 - EXECUTION (NOT USED)

END OF SECTION 22 30 01
PART 1 - GENERAL

1.01 SCOPE OF WORK

A. The Work of this Section includes providing all labor, materials, accessories, services and tests necessary to install new plumbing fixtures and trim complete and make ready for operation by the Owner, all work as shown on Drawings and as specified hereinafter.

PART 2 - PRODUCTS

2.01 GENERAL

A. Plumbing fixture type and installation shall be in accordance with National Plumbing Code.

B. All fixture trimmings, including escutcheons, stops, traps, visible hangers nuts shall be made of brass and shall be polished chromium plated.

C. Each fixture supply shall be separately controlled by its own stops. Locate as required on wall, above floor or as directed.

D. All faucets shall have metal handles.

E. All trims shall be permanently stamped with manufacturer's identification and visible after installation.

F. All fixtures and faucets designated for the use by the handicapped shall be barrier-free type.

G. Provide Pro-Wrap seamless insulators on all exposed piping under sinks and lavatories designated for the handicapped.

2.02 PLUMBING FIXTURE SCHEDULE [SEE SCHEDULE ON DRAWINGS]

PART 3 - EXECUTION

3.01 SERVICES TO FIXTURES AND EQUIPMENT FURNISHED UNDER OTHER SECTIONS

A. Review the list of equipment for the project and include in the Contract price the costs for installing all equipment as herein specified.

B. Refer to Architectural, Equipment and Plumbing Drawings for exact locations of equipment and fixtures. Provide all materials, equipment and appliances necessary and required to complete the installation of all Laboratory casework and equipment, including but not limited to the
following: plumbing, roughing and final connections, valves, stops, trim, escutcheons, fittings, traps, etc. Install faucets, trim, etc., furnished with the equipment provided by others.

C. Unless otherwise detailed on Drawings, roughing of proper size and capacity for equipment indicated on Architectural, Heating and Ventilation, Plumbing or Electrical Drawings or provided under another Division or Section shall be provided and installed in such a manner and location that final connection can be made with a minimum of work and without cutting, patching permanent walls, partitions, ceilings or floors. Drawings are of necessity, schematic, for special equipment as exact roughing and requirements may vary with different manufacturers.

3.02 INSTALLATION

A. Make all plumbing connections to all equipment and fixtures requiring such connections as shown on Drawings whether the equipment and fixtures are furnished under this Section or another Division or Section (except as noted otherwise), including installations of all special traps, supplies, control valves furnished with such equipment, and furnish all material necessary that is not supplied with the equipment.

B. Leave valved water connection for equipment, spaces and other locations where shown for the use of other trades or other Sections.

C. As soon as installed, all metal fixture trimming shall be thoroughly covered with non-corrosive grease which shall be maintained until all construction work is completed.

D. Upon the completion of the Work, all fixtures and trimmings shall be thoroughly cleaned and polished and free from all marks and left in first-class condition.

E. Upon completion of the Work, test flush valves and faucets for leaks or drips and adjust same for quiet operation.

F. Equipment and all connections shall be in accordance with the rules relative to submerged inlets and shall be provided with all necessary vacuum breakers and check valves in accordance with the applicable codes.

G. All fixtures shall be left thoroughly clean. All plated or polished fittings, pipes and appliances shall be coated with Vaseline immediately after installation, and shall be finely polished and free from all marks and foreign substances.

H. Equipment and all connections shall be in accordance with the rules relative to submerged inlets and shall be provided with all necessary vacuum breakers and check valves in accordance with the applicable codes.

I. Connection between any fixture with a floor outlet and flange shall be made with a prepared gasket that shall be a germicide, absolutely gas and fume-proof, watertight, stain-proof, containing neither oil nor asphaltum, and which shall not rot, harden or dry under any extreme climate change and must adhere on wet surfaces.
J. Each fixture shall be separately trapped, using the type and size of trap called for specifically in the Specifications or the type required by the Plumbing Code.

K. All fixtures requiring hot and cold water shall have the cold water faucet on the right hand side of the fixture and the hot water faucet on the left hand side of fixture.

L. Protect all plumbing fixtures, equipment, etc., against injury from building materials, acids, tools and equipment.

M. No slip joints shall be permitted on water piping.

N. Flexible supplies shall not be permitted in lieu of rigid supplies.

END OF SECTION 22 40 00
PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section is coordinated with and complementary to the General Conditions and Special Conditions of the Work, wherever applicable to Mechanical and Electrical Work.

B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

C. Section 22 05 02 - General Provisions for Plumbing work shall apply.

1.02 SCOPE OF WORK

A. Work under this Section shall include furnishing, installing, and testing the complete oxygen, nitrous oxide, nitrogen, vacuum, and compressed air pipeline systems, including pipe, pipe fittings, valves, outlets, alarms, etc., and connections to the new existing systems, as shown on the Contract Drawings and herein specified.

B. All systems shall be left completed in every respect and ready to be put into full operation. All materials used shall be new and of the best grade and quality obtainable. Workmanship shall be first class in every respect.

C. The requirements and recommendations of the National Fire Protection Association (NFPA) as set forth in Pamphlets No. 99 and 50 shall apply to this installation and shall be adhered to in all respects. This Contractor shall be responsible for compliance with all local, state or federal codes applicable to this installation.

D. The stock and model numbers of equipment listed in the following paragraphs identify equipment manufactured by Ohmeda Products. Equipment of other manufacturers may be considered as equal upon approval of the Architects and/or Owner.

E. Except for pipe and pipe fittings, all medical gas, air and vacuum components, including manifolds, outlets, valves, alarms, etc., shall be procured from a single source supplier.

F. Patient wall systems and wall mounted consoles containing medical gas outlets are furnished and installed under other Sections or Divisions of these Specifications. This Contractor shall provide all required gas services for the wall units.

G. Medical gas, air and vacuum outlets including columns, shall be provided by this Contractor.

H. Piping material shall be as specified in Section 22 10 01.

I. Master and local alarms and accessories shall be provided under this Section and wired under other Sections of these Specifications.
1.03 QUALITY ASSURANCE

A. The Contractor installing the medical gas system piping shall have had experience in the installation of at least two other medical gas systems of similar size.

B. Submit the name of the installing Contractor and a list of his experience and references.

PART 2 - PRODUCTS

2.01 SERVICE OUTLETS

A. Wall outlets and outlets furnished in wall units and wall consoles shall be Beacon Madeas, Diamondcare type.

B. Provide a vacuum slide plate next to each vacuum outlet.

C. Where two or more gas service outlets are required at one location, provide a gas service outlet assembly. The roughing-in assembly shall be suitable for singular or modular design.

D. Medical gas wall outlets shall be Diamondcare quick connect and shall be suitable for O₂, N₂O, vacuum, anesthetic waste gas evacuation, and air. Outlets shall be designed and manufactured in accordance with applicable NFPA, CGA, and CSA Standards and shall be listed by Underwriters' Laboratories, Inc. All outlets shall be cleaned for oxygen service and tested prior to shipping.

E. The roughing-in assembly shall be of modular design such that any combination of individual medical gas outlets and vacuum bottle-mounting slide brackets can be ganged together in any sequence desired. The design shall permit adding or deleting outlets from any ganged assembly, or to rearrange the sequence of medical gas services in order to comply with Owner/Architect requirements.

F. The roughing-in assembly shall consist of a die-cast aluminum back plate with mounting flanges on all 4 sides, a 1/2” raised plaster strike, and a non-removable positive pin keying arrangement for each specific gas service. Identification of the specific gas service shall be permanently cast into the back plate; adhesive labels shall not be acceptable. The secondary check assembly with a 7” length of 3/8” O.D. type K copper tubing shall be mounted to the backplate. The tubing shall have a label affixed which identifies the specific gas service by name and color, and a plastic dust cap on the end of the tubing extension. The design shall permit 360 degree rotation of the inlet tubing for ease of connection to gas supply from any direction. The secondary check valve shall be completely serviceable from the front allowing for removal of all seals and check components. A transparent plastic guard covering the raised plaster strike area shall permit viewing the condition of the interior and prevent the entry of foreign material and debris during installation and finishing of the walls.

G. The design of the secondary check, including vacuum outlets, shall be such that a positive seal automatically prevents gas flow when the finishing assembly is removed for maintenance or service.
H. In order to provide flexibility for conversion from quick-connect to DISS, or vice versa, the roughing-in assembly shall accept either quick-connect and DISS finishing assemblies and shall be readily interchangeable for the same gas without requiring disassembly or rearrangement of internal components of the roughing-in assembly.

I. The finishing assembly shall consist of a die cast chrome plated cover plate, a machined brass housing for the primary check valve, and positive pin keying devices to prevent transposition of gas services during installation. Mounting screws on the front body finishing assembly shall automatically compensate for up to 1/2" over standard 1/2" wall finish thickness. When two or more outlets are ganged together in series the entire assembly shall give the appearance of one continuous gas service console that automatically provides 4-1/2" spacing between center lines of gas service outlets to facilitate the use of patient treatment devices. Each individual gas service of a ganged assembly shall have a separate cover plate.

J. The cover plate shall not leave any visible gap when butted to adjacent cover plates of ganged assembly. The finishing assembly shall incorporate a double seal arrangement which operates simultaneously when a hose connector or patient treatment device is removed from an outlet in order to assure a leak-free outlet when not in use.

K. A minimum surface area of 2.5 spare inches of appropriate color shall be incorporated into permanently affixed components located on the finished surface of the outlet. A permanently affixed nameplate identifying the gas service on the finished surface of the outlet shall contain letters not less than 3/16" high and shall incorporate appropriate color coding.

L. The quick-connect finishing assembly shall be designed with an integral color-coded keying disc. The design of the primary check shall be such that absolutely no gas flow can take place until the keying devices are engaged.

M. The recessed mounting box shall be injection molded ABS Cycolac material and shall result in a neat appearance with no internal mechanical components visible.

N. Service Outlet Schedule

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<tr>
<td>EVAC</td>
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</table>

2.02 VALVE BOX ASSEMBLIES

A. Valves in finished areas shall be installed in recessed valve boxes. Two or more valves of different gases shall be installed in one box for control of services to zoned area.

B. The recessed valve box assemblies shall consist of an extruded aluminum finish frame with pull-out window, roughing-in assembly with extruded aluminum back box containing one or more electroplated ball type shut-off valves, and tubing extensions with color-coded gas service labels affixed. The valve box assemblies shall be provided with line pressure monitoring gauges mounted down-stream from the shut-off valves.
The finish frame shall be of single piece welded aluminum with etched and anodized finish, and shall attach to the roughing-in assembly with concealed mounting screws allowing plaster adjustment up to one inch. Contained within the finish frame shall be a clear, removable vinyl window with pull ring attached in the center; when pulled it will remove the window for access to the valve(s). The window shall have the ability to be replaced in position without the use of tools only after the valve handle has been returned to the open position. The window shall contain a label reading: CAUTION - CLOSE ONLY IN EMERGENCY - PULL RING FOR ACCESS.

The roughing-in assembly shall be constructed of an extruded aluminum back box with back plate, 1/2" deep plaster flange on all four sides for securing assembly to structural wall; and a pull-out plaster guard to prevent debris from entering the back box during installation. A label with mounting bracket which can be marked to identify rooms or area controlled shall be supplied for each valve. The label(s) shall be mounted directly behind the vinyl window for ease of visibility.

The valves shall be bronze bodied, double seal, bolted union type ball valve, with swing-out body for ease of installation and service, designed for working pressures up to 400 psi, with chrome plated bronze ball which seals in both direction, double O-ring stem seal and self-compensating bearings to guard against leakage due to wear. Tubing extensions shall be factory brazed to the valve flanges for connection to piping outside the box. Valves and tubing extensions shall be electroplated, except for approximately 4" of bare surface for brazing, preassembled, pressure tested, cleaned, capped, and rigidly mounted to the back box for ease of installation. The valves shall require only a quarter turn of the handle to completely open or close. Downstream from the shut-off valve in the tubing extension shall be mounted on a 1-1/2" diameter line pressure monitoring gauge, which shall be visible through cover window. The assembly shall be Model SSB-821-01 Series. For valve stock No. refer to Section 221002.

2.03 LINE PRESSURE ALARM PANELS (LOCAL ALARM)

Secondary local audible and visual recessed medical line pressure gas alarms with built in pressure gauges shall be provided for the medical gas services. They shall be located in the Nurses Station or as indicated on the Drawings.

The self-contained line pressure and line vacuum alarms shall be a closed circuit, self-monitoring type. Alarm shall be used to monitor oxygen, nitrous oxide, vacuum, evacuation, and compressed air. A green NORMAL light will glow for all systems normal. If any monitored line goes high or low, the green light will go out and both an audible warning device will sound and the LINE PRESSURE ABNORMAL red light will come on. The built in gauge will indicate the pressure or vacuum at all times. A switch is supplied to silence the warning device, however, the LINE PRESSURE ABNORMAL light shall remain on until the condition has been corrected. If two or more LINE PRESSURE ABNORMAL conditions occur, their condition will be indicated on the alarm until corrected. Only after all conditions have been corrected will the NORMAL light glow again. A test switch shall be supplied to test all internal circuits, light bulbs and the audible warning device. Alarm shall be complete, with internal switches, gauge, solid-state control unit, and 115/24 volt transformer. An 8 inch length of 1/4 inch nominal I.D. type K copper tubing swedged at the end, shall be supplied for connection to the service line.
C. The roughing box shall be extruded aluminum with flanges on all four sides for recessed installation and shall include terminal blocks and protective plaster shield.

D. The finishing coverplates shall be die cast with chrome plated border and background, designed to provide ¾” overplaster adjustment.

E. Secondary local alarms shall be Mega 3 Area Alarm Panel SSB-835-01 or approved equal.

2.04 VACUUM AND EVACUATION PRESSURE SWITCHES

A. The vacuum and evacuation switches shall be of the single pole double throw, snap action type and may be wired to cut in or out on either increasing or decreasing vacuum. The switch is controlled by a copper bellows vacuum sensing system, which has been cleaned in compliance with NFPA recommendations for use with medical gases. The vacuum switch shall have an adjustable range of 30 inches of mercury vacuum to 10 pounds per square inch pressure, adjustable differential to 4 to 4 psi (.8 to 8 inches of mercury for vacuum). Contacts of switch rated 5 amperes at 240 volts A.C. non-inductive. The switches shall have vacuum adjustment dial, differential adjustment dial and range indicator located on the front center panel of the vacuum switch assembly for ease of access and reading. The assembly shall provide for three electrical terminals at the top of the switch for connection to the alarm system. The vacuum switch assembly shall be housed in a NEMA 1 general purpose enclosure with ¼” 18 NPTF gas service connection at the bottom and a ⅞” diameter clearance hole for electrical conduit connection at the top of the housing.

2.05 PRESSURE SWITCHES FOR OXYGEN, NITROUS OXIDE AND COMPRESSED AIR

A. The oxygen and nitrous oxide and air high-line pressure switch shall consist of a dual circuit with two single pole, double throw, snap action switches having U.L. approval. The switches are controlled by a copper diaphragm type pressure capsule which has been cleaned in compliance with NFPA recommendations for use with medical gases. The pressure switch shall be prewired with six 18" lengths of color coded wires which extend above the 3/4” N.P.T. conduit connection provided. The electrical inductive rating shall be 10 amperes at 120 volts alternating current. The pressure switches shall be tested at 180 psi with an adjustable range of 3.8 to 100 psi, preset at 40 and 60 psi (plus or minus 2 psi), and have two external calibrated circular dials with tamper proof cover.

B. The pressure switch shall be constructed of a rugged cast, NEMA 4 weatherproof housing with mounting bracket, and a ¼” NPT gas service line connection at the bottom of the assembly.

2.06 ORIFICE NIPPLES

A. An orifice nipple shall be provided for use between each piped gas system and each pressure or vacuum switch. It shall limit the amount of leakage from the system, thus allowing repair or replacement of the switch without shutting down the system.

B. The orifice nipple shall be made of brass, have a .020” orifice hole, and ¼” NPT male thread at each end.
2.07 DRAINS

A. For low points of vacuum, evacuation and air piping, provide valved drip legs and ½ inch brass petcock drains Crane No. 700 or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION OF MEDICAL GAS PIPING SYSTEMS

A. All piping, valves, fittings, and other components for all nonflammable medical gas systems shall be purchased and shipped cleaned of oil, grease, and other readily oxidizable materials as if for oxygen service. Particular care shall be exercised in the storage and handling of such material. Such material shall be temporarily capped or plugged to prevent recontamination before final assembly. Just prior to final assembly, such material shall be examined internally for contamination and shall be recleaned if necessary.

Such material shall be delivered capped or plugged and shall be inspected prior to final assembly. If necessary, recleaning shall be done as follows:

Piping, valves, fittings, and other components prepared at the job site shall be cleaned by washing in a hot alkaline cleaner-water solution, such as sodium carbonate or trisodium phosphate (proportion of one pound to three gallons of water). Scrubbing shall be employed where necessary to ensure complete cleaning. After washing, the materials shall be thoroughly rinsed in clean, hot water.

B. All brazed joints in the piping shall be made up using brazing filler alloys that bond with the base metals being brazed and that comply the Specification for Brazing Filler Metal, ANSI/AWS A5.8.

1. Copper-to-copper joints shall be made using a copper-phosphorus brazing filler alloy (BCuP series) without flux.

2. Dissimilar metals such as copper and brass shall be joined using an appropriate flux with either a copper-phosphorus (BCuP series) or a silver (BAg series) brazing filler alloy. Apply flux sparingly and in a manner to avoid leaving any excess inside of completed joints. Use of prefluxed rod is acceptable.

Note: Some BAg series filler metals contain cadmium, which, when heated during brazing, can produce toxic fumes.

3. While being brazed, joints shall be continuously purged with an inert gas such as dry nitrogen or carbon dioxide to prevent the formation of scale within the tubing.

4. A visual inspection of each brazed joint shall be made to assure that the alloy has flowed completely in and around the joint and, where flux has been used, that hardened flux has not formed a temporary seal that holds test pressure. The outside of all fluxed joints shall be washed with hot water after assembly to remove excess flux for clear visual inspection of brazed connections.

5. The outside of all tubes, joints, and fittings shall be cleaned by washing with hot water after assembly.

C. Threaded joints in piping systems shall be tinned or made up with polytetrafluoroethylene (such as Teflon) tape or other thread sealants suitable for oxygen service. Sealants shall be applied to the male threads only.
D. Threaded connections between the regulators and the piping system shall comply with Compressed Gas Association Standard V-5, Diameter-Index Safety System.

E. Flexible connectors of other than all-metal construction used to connect outlets of pressure regulators to fixed piping shall not exceed 5' (1.5m) in length and shall not penetrate walls, floors, ceilings, or partitions. Flexible connectors shall comply with the provisions of 4-4.2.3.

F. A shutoff valve or check valve shall be installed downstream of each pressure regulator.

G. A pressure relief valve set at 50% above normal line pressure shall be installed downstream of the shutoff or check valve. Pressure relief valves shall be of brass or bronze and designed for oxygen service.

3.02 LABELING OF PIPING

A. All pipe and tubing shall be labeled or painted to indicate its gas content. Metal tags, stenciling, or adhesive markers may be used if affixed so as not to be readily removable. Labeling shall appear on the pipe at intervals of not more than 20 feet, at least once in every room and each story transversed by the pipeline. Where a color code is used, colors shall conform to the standards as used throughout the medical gas industry. Refer to Section 01 31 46.

3.03 TESTING

All medical gas systems shall be tested in accordance with NFPA-99. Nitrogen shall be used for the test gas for all systems.

A. Cross-Connection: Before piping systems are initially put into use, the Contractor shall be responsible for ascertaining that the gas delivered at the outlet is that shown on the outlet label and that the proper connecting fittings are checked against their labels.

1. To determine that no cross-connection to other piping systems exists, reduce all medical gas systems to atmospheric pressure. Disconnect all sources of test gas from all of the medical gas systems with the exception of the one system to be checked. Pressure this system with nitrogen to 50 psig. With appropriate adapters matching outlet labels, check at least 10 individual station outlet of all medical gas systems installed to determine that test gas is being dispensed only from the outlets of the medical gas system being tested.
   a. Disconnect the source of test gas and reduce the system tested to atmospheric pressure. Proceed to test each additional piping system.

B. Cleaning/Purging/Purity for Gas Systems: After installation of the piping, but before connection of the station outlets and other medical gas system components (e.g., pressure-actuating switches for alarms, manifolds, pressure gauges, or pressure relief valves), the line shall be blown clear by means of nitrogen.

1. Purging: After all medical piping systems have been tested for cross-connection, the source of test gas shall be disconnected and the proper gas source of supply connected to each respective system. Following this connection and pressurization, all existing outlets shall be opened in a progressive order, starting nearest the source and completing the process of purge flushing at the outlet farthest from the source.
   Purge gas shall be allowed to pass through a white cloth material at a minimum flow rate of 100 liters per minute until no discoloration is evident and the test gas used during the previous tests has been removed from the piping systems.
2. Analysis: After completing the purge flushing of the piping system, the flow of gas from each existing station outlet for oxygen and nitrous oxide shall be tested with an oxygen analyzer to confirm the presence of the desired percentage of oxygen.

C. Valves installed in each medical gas piping system shall be tested to verify proper operation.

D. A visual inspection of each brazed joint shall be made to assure that the alloy has flowed completely into and around the joint and, where flux has been used, that hardened flux has not formed a temporary seal that holds test pressure. Remove all excess flux for clear visual inspection of brazed connections.

E. Pressure testing:
   1. Before attachment of system components (e.g., pressure-actuating switches for alarms, manifolds, pressure gauges, or pressure relief valves), but after installation of the station outlets, with test caps (if supplied) in place (e.g., rough-in assembly), and before closing of the walls, each section of the piping system shall be subjected to a minimum test pressure of 150 psig with nitrogen. This test pressure shall be maintained until each joint has been examined for leakage by means of soapy water or other equally effective means of leak detection safe for use with oxygen. The source shutoff valve shall be closed.
      a. After the piping system is filled with test gas, the supply valve and all outlets shall be closed and the source of test gas disconnected. The piping system shall remain leak-free for 24 hours. When making the standing pressure test, the only allowable pressure changes during the 24-hour test period shall be those caused by variations in the ambient temperature around the piping system. Such changes can be checked by means of the pressure-temperature relationship: calculated final absolute pressure (absolute pressure is gauge pressure plus 14.7 psi if gauge is calibrated in psi) equals the initial absolute pressure times the final absolute temperature (absolute temperature is temperature reading plus 460°F if thermometer is calibrated in Fahrenheit degrees), divided by the initial absolute temperature.
      b. Leaks, if any, shall be located, repaired, and retested.
   2. After testing of each individual medical gas system as indicated above and before connecting to the existing system, the completely assembled station outlets and all other new medical gas system components (e.g., pressure-actuating switches for alarms, manifolds, pressure gauges, or pressure relief valves) shall be installed and all piping systems shall be subjected to a 24-hour standing pressure test at 20% above the normal operating line pressure. The test gas shall be nitrogen. The source shutoff valve shall be closed.
      a. The final connection between the addition and existing system shall be leak tested with the source gas at the normal operating pressure. This pressure shall be maintained until each joint has been examined for leakage by means of soapy water or other equally effective means of leak detection safe for use with oxygen.
      b. Flexible connectors, metallic or nonmetallic, shall have a minimum burst pressure of 1000 psig.
   3. Piping systems, with the exception of nitrogen systems, shall be capable of maintaining 50-55 psig to all outlets at the maximum flow rate.

F. Outlet tests:
   1. Piping systems, with the exception of nitrogen systems, shall be capable of maintaining 50-55 psig to all outlets at the maximum flow rate.
2. Nitrogen system shall be capable of delivering at least 160 psig to all outlets at maximum flow.

G. Alarm Testing for Gas Systems:
1. All warning systems for each medical gas piping system shall be tested to assure that all components function properly prior to placing the piping system in service. Permanent records of these tests shall be maintained. Test shall be in accord with Appendix C-4.2 of NFPA 99.

END OF SECTION 22 60 01
PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. This Section is coordinated with and complementary to the General Conditions and Supplementary General Conditions of the Work, wherever applicable to Mechanical Work.

B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

1.02 DESCRIPTION OF WORK INCLUDED

A. Work Included:
   1. The work includes providing all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all Heating, Ventilating and Air Conditioning Work as shown on the Drawings and hereinafter specified, including, but not limited to the following:
      a. All motor starters and controllers for equipment furnished by this Contractor. Packaged type units shall be furnished completely prewired with panels mounted on the units as specified. All other motor starters and controllers will be turned over to the Electrical Contractor for installation and wiring.
      b. Filters.
      c. Fans.
      d. Cabinet and unit heaters, finned tube radiation and convectors.
      e. Provide isolation valves where tying new piping into the existing system. Refer to the valves specifications for the proper valve type for the service. Refer to the Drawings for the pipe/valve size. In addition to the isolation valves at the tie-in points, also provide a balancing valve on the supply side for heating/reheat hot water system tie-ins.
      f. Hot water specialties such as expansion tanks, air vents, air separators, reducing and safety valves, etc.
      g. Accessories such as V-belt drives, flow measuring devices, draft gauges, machinery guards, thermostats, pressure gauges.
      h. Water treatment for hot water systems.
      i. Inertia blocks and vibration isolation equipment.
      j. Piping, fittings, and valves.
      k. Sheet metal ductwork and accessories such as dampers, access doors, etc.
      l. Registers, grilles and diffusors.
      m. Fire dampers and smoke dampers.
      n. Installation of smoke detectors in ductwork.
      o. Acoustical duct lining.
      p. Pipe, duct and equipment insulation.
      q. Computer room air conditioning systems.
      r. Constant and variable volume air terminals.
      s. Temperature Control: A complete system of temperature control shall be installed in connection with the HVAC systems, including all thermostats, control valves,
damper motors and dampers for the outdoor air intakes and fan discharges. All control wiring for automatic temperature controls, including interlocking wiring for fans, chillers, pumps, etc. by this Contractor.

t. Painting and pipe, duct and equipment identification for all work by this Contractor is previously specified under "Special Requirements for Mechanical and Electrical Work".

u. Test and balancing.
v. Sleeves, pipe inserts and anchor bolts, escutcheons, prefabricated roof curbs, etc., as hereinafter specified.
w. Identification, name plates, tags and charts.
x. Cutting and rough patching.
y. Furnishing and setting of electric motors.
z. Furnishing of starters, motor control centers and motor control devices as specified under "Special Requirements for Mechanical and Electrical Work".

aa. Templates and anchor bolts for equipment bases.
bb. Cap flashing for pipe and duct passing through roof.
cc. Removal, relocation and/or demolition of existing HVAC work in conjunction with the existing buildings in order to erect the new buildings as indicated on the Contract Drawings.


A. The following work is included under other Sections of the Specifications:
1. Framed openings as shown on the Drawings.
2. Trenches and covers.
3. Valved water supply outlets within 5'-0" of the various pieces of the HVAC equipment will be left by the Plumbing Contractor. Final connections to HVAC equipment shall be made by this Contractor. Gas supply shall be within 5'-0" of equipment.
4. Floor and funnel drains adjacent to equipment requiring same will be furnished and installed by the Plumbing Contractor.
5. Domestic hot water generators including all domestic water piping thereto. Steam and condensate final connections by this Contractor.
6. Outside air inlets, exhaust outlets, louvers and screens through walls, and elsewhere as noted on the Drawings. Motorized dampers furnished and installed under this Contract.
7. Base flashing of curbs and sleeves at roofs.
8. Power wiring for all motors except where otherwise noted.
9. Foundations for oil and diesel oil tanks as specified and shown on the Drawings.
10. Temporary heat.
11. Setting of access doors furnished by this Contractor.
12. Undercutting of doors or louvers in doors.
13. Diesel electric generator, muffler, day tank and flexible connectors. Installation of muffler, day tank, flexible connectors under this Section.
14. All motor disconnect switches, except where in combination starters and where otherwise noted.
15. Finish painting.
17. Finish patching.
18. Ventilating hoods - kitchen, labs, etc.
19. Wiring of switches, aquastats, pressure controls in power circuit of cabinet and unit heaters.
20. Fan shutdown system.

1.04 QUALITY ASSURANCE

A. Perform work in accordance with quality established in Section 01 31 46 "Special Requirements for Mechanical and Electrical Work", and hereinafter specified. All work performed shall comply with local codes.

1.05 SUBMITTALS

A. Submit shop drawings covering the following items:
1. Coordination drawings.
2. Internal cleaning and treating of piping.
3. Sleeve and ductwork penetration drawings.
4. Identification schedule and samples.
5. Air handling units.
6. Air filters and draft gauges.
7. Coils.
8. Expansion joints, anchors and guides, including details of installation.
9. Air diffusers, registers and grilles.
10. Schedule of ductwork, joints, gauges, supports, flexible connections, fire dampers, access doors, etc.
11. Utility fans, centrifugal fans, and power roof ventilators and propeller fans.
12. Sheet metal fabrication drawings.
15. Schedule of piping and fitting materials.
16. Piping shop drawings.
17. Schedule of valves, strainers, vacuum breakers.
18. Thermometers and pressure gauges.
19. Computer room air conditioning system.
21. Schedule of pipe and ductwork supports, including inserts, escutcheons, etc.
22. Heating systems, including unit heaters, cabinet heaters, fin tube radiation convectors, etc., as specified.
23. Outside air supply unit including coils, filters, draft gauges, etc.
24. Fan coil units.
25. Water pumps including pump curves.
26. All motor starters, motor control devices and motor control centers.
27. Water treatment equipment and systems.
28. Schedule of insulation types and samples of each type.
29. Vibration isolation schedule including inertia block details.
30. Templates for equipment bases.
31. Acoustic material.
32. VAV and constant air valve boxes. Dual duct constant air volume units.
34. Air vents, air separators, water strainers, reducing and safety valves for water systems.
35. Diesel generator system.
36. Automatic Temperature Control System.
37. Concrete pad locations and sizes.

B. All shop drawings being submitted that include electrical work shall be submitted with all internal and external wiring diagrams.

C. The previously listed items are major equipment and do not limit this Division's responsibility to submit shop drawings for all equipment and accessories which are to be provided under this Division of the Specifications.

PART 2 - PRODUCTS

2.01 SPARE PARTS

A. Filters:
1. The Contractor shall furnish a minimum of two complete spare filter sets for the filters for all air handling and package AC units. Provide 40 spare filters for fan coil units.

B. Spare Lamps:
1. Furnish ten (10) spare lamps for each size and type of lamp on instrument panels.

C. Miscellaneous Spare Parts:
1. Furnish one complete set of V-belts for each belt driven unit installed.
2. Electrical equipment - two spare starter fuses identified for each type and size for all starters including pumps, supply, return and exhaust fan.
3. One set of bearings properly identified for each type and size supply, return and exhaust fan.
4. For each type and size pump furnished under this section of the contract, furnish as applicable for each type and size of pump, one set of wearing rings, one set of mechanical seals, one set of bearings, one set of shaft sleeves, one set of stuffing box bushings, one set of packing glands with rings, nuts and bolts and sufficient stuffing box packing for four packings.

D. Furnish tools required for equipment as follows:
1. One set of high grade tools as recommended and approved by the respective manufacturer for pumps, fans, refrigeration equipment and other equipment. Tools shall be furnished in a suitable hardwood or other approved container with lock and two (2) keys. Pasted on the inside cover shall be a list of all tools provided in container.
2. One pressure grease gun of approved design and size, complete with necessary adaptors to fit all lubricating fittings on installed equipment.
3. One pitot tube, complete with required manometers, to read static pressure and velocity pressure simultaneously. Provide 6'-0" of rubber tubing.
2.02 LIST OF MANUFACTURERS

A. The manufacturer's name appearing first on this list is the manufacturer the project design was based upon. However, the additional manufacturers listed herein are also acceptable with the provision that they meet the requirements of these Specifications, ratings, and/or space allocations listed in the Specifications or shown on the Drawings.

1. Water Pumps
   a. Bell & Gossett
   b. Weinman
   c. Goulds
   d. Paco
   e. Grundfos
   f. Patterson
   g. Armstrong
   h. Taco
   i. or approved equal

2. Air Conditioning Units
   a. York
   b. Trane
   c. Carrier
   d. Envirotech

3. Fan Coil Units
   a. International
   b. Williams
   c. Titus
   d. Envirotech
   e. Carrier
   f. Trane

4. Duct Terminal Units
   a. Anemostat
   b. Price
   c. Trox
   d. Nailor
   e. Envirotech

5. Fresh Air Supply Units
   a. American Air Filter
   b. Trane
   c. Carrier
   d. Envirotech

6. Water Coils
   a. American Air Filter
   b. Trane
   c. York
   d. Carrier
   e. or approved equal

7. Diffuser Section for Air Handling Units
   a. American Air Filter
   b. Cambridge
   c. York
8. Air Filters
   a. American Air Filter
   b. Camfill Farr
   c. Cambridge
   d. or approved equal

9. Centrifugal Fans and Utility Sets
   a. Cook
   b. Greenheck
   c. Buffalo
   d. ACME
   e. New York Blower
   f. Twin Cities
   g. or approved equal

10. Propeller Fans
    a. Peerless
    b. Greenheck
    c. ACME
    d. or approved equal

11. Heat Exchangers
    a. Bell and Gossett
    b. Patterson - Kelley
    c. Yula Corp.
    d. approved equal

12. Cabinet & Unit Heaters
    a. Vulcan
    b. Trane
    c. Modine
    d. Sterling
    e. or approved equal

13. Finned Tube Radiation and Convecors
    a. Vulcan
    b. Trane
    c. Sterling
    d. or approved equal

14. Louvers & Dampers
    a. Arlan Damper Corp. (631-589-7431)
    b. Ruskin
    c. Titus
    d. or approved equal

15. Water Specialties
    a. Bell & Gossett
    b. Taco
    c. Armstrong
    d. or approved equal

16. Expansion Joints
    a. Zallea
    b. Flexonics
    c. Flex Hose
17. Thermometers & Pressure Gauges
   a. Ashcroft
   b. Weiss Instruments
   c. or as specified in Section 23 05 80

18. Motors
   a. General Electric
   b. Westinghouse
   c. Allis Chalmers
   d. or approved equal

19. Starters, Motor Control Centers, Switches
   a. Allen Bradley / Rockwell
   b. Square D
   c. General Electric
   d. Westinghouse
   e. Cutler-Hammer
   f. or approved equal

20. Diffusers, Registers & Grilles
    a. Titus
    b. Price
    c. Anemostat
    d. Acutherm
    e. Nailor

21. Valves
    a. Jenkins
    b. Crane
    c. Walworth
    d. or as specified under paragraph on "Valves"

22. Insulation and Acoustic Lining
    a. Owens-Corning Fiberglass Corp.
    b. CSG Snap-on
    c. Johns Manville
    d. or approved equal

23. Vibration Isolation
    a. VMC East
    b. Mason Industries
    c. Korfund Corp
    d. or approved equal

24. Automatic Temperature Controls
    a. Johnson Controls
    b. Honeywell
    c. Siemens
    d. Andover
    e. Alerton
    f. Automated Logic

25. Water Treatment
    a. Heating Economy Services, Co., Inc.
    b. Astro Pak Corp.
    c. Okite Chemical Corp.
d. Drew Chemical Corp.
26. Internal Cleaning & Treating of Piping
   a. Heating Economy Services Co., Inc.
   b. Tower Water Management
   c. The Metro Group, Inc.
   d. Drew Chemical Co.
27. Electric Heating Elements
   a. Qmark
   b. Indeeco
28. Ductless Split DX Air Conditioning Units
   a. Mitsubishi
   b. Sanyo
   c. Trane
   d. Daikin

PART 3 - EXECUTION (NOT USED)

END OF SECTION 23 05 12
PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
   A. This Section is coordinate with and complementary to the General Conditions and Supplementary General Conditions of the Work, wherever applicable to Mechanical Work.
   B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

1.02 DESCRIPTION OF WORK
   A. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all Valves as shown on the drawings and hereinafter specified.

1.03 QUALITY ASSURANCE
   A. "Manufacturers" - Firms regularly engaged in manufacture of valves, whose products have been in satisfactory use in similar service for not less than 10 years.
   B. Provide valves produced by the manufacturers, which are listed in Section 23 05 12, "Approved Manufacturer's List".
   C. Provide valves whose performance under specified conditions, is certified by the manufacturer.
   D. To assure uniformity and compatibility, all grooved end valves and adjoining couplings shall be supplied by a single manufacturer.

1.04 SUBMITTALS
   A. Refer to Section 01 31 46 - Special Requirements for Mechanical and Electrical Work and submit shop drawings.

1.05 GUARANTEE
   A. Refer to Section 01 31 46 - Special Requirements for Mechanical and Electrical Work.

PART 2 - PRODUCTS

2.01 VALVES
   A. Valves- General: All valves shall be of a design which the manufacturer lists for the service and shall be of materials allowed by the latest edition of the ASME Code for pressure piping for the pressure and temperature contemplated, unless a higher grade or quality is herein specified. All valves of the same type shall be of the same manufacturer, except for special applications.
B. The system shall be supplied with valves in all branch mains and risers, at all pumps, tanks, reducing and control valves, heating and cooling surfaces and at all apparatus; so located, arranged and operated as to give complete shut-off. Except where flanged valves are used, each connection to equipment shall be made with screwed unions, flanged unions, or grooved couplings on the equipment or discharge side of the valve.

C. All valves shall be installed and arranged so that they are easily accessible.

D. Each valve shall have the maker's name or brand, the figure or list number and the guaranteed working pressure cast on the body or stamped on the bonnet, or shall be provided with other means of easy identification.

E. Check valves installed in the horizontal position shall be swing checks; valves installed in the vertical position shall be silent checks for 2½" and above, and lift check for 2" and smaller, except that all check valves in pump discharges shall be silent checks.

F. Provide isolation valves where tying new piping into the existing system. Refer to the valves specifications for the proper valve type for the service. Refer to the Drawings for the pipe valve size. In addition to the isolation valves at the tie-in points, also provide a balancing valve on the supply side for chilled water, chilled glycol/brine, condenser water and heating/ reheat hot water system tie-ins.

G. Provide capped blow-off valves at all strainers, and where shown on the Drawings.

H. Provide valve operating chain on all gate, globe, butterfly and plug valves in Mechanical Equipment Rooms - 4" and larger, which are more than 7'-0" above the operating floor. Unit shall be complete with adjustable sprocket, chain and guide (Crane "Babbit" type). Provide hook to keep chain out of the way.

I. Generally, all valves are to be of the gate type, except that globe valves shall be used for balancing service, throttling services and on traps, and pressure reducing and control valve bypasses. Globe valves used on bypasses shall have monel metal mountings. Pumps shall have globe type balancing flow measuring & shut off valves on discharge piping.

J. All valves 2 inches in diameter and smaller shall be all bronze with bronze bodies. Valves 2½ inches in diameter and larger shall have iron bodies with bronze mountings (except where otherwise noted).

K. All flanged-end valves shall have renewable metal seat rings and discs. On gate valves these parts shall be of bronze, on all globe valves they shall be of bronze and suitable for throttling service.

L. Grooved-end valves may be used in lieu of threaded, flanged, lug or wafer valves, if and where grooved end piping is used. All grooved-end valves shall be complete with grooved ends for use with mechanical couplings of the same manufacturer. Valve sealing elastomer shall be of the same composition as the adjoining coupling gaskets.
   1. Grooved End Butterfly Valves:
a. 2"-12": ASTM A395 and A536 ductile iron body and disc, with integrally cast stem. Disc shall be nickel-plated. Body coated with Black enamel. Victaulic Vic-300 MasterSeal™.
b. 14"-24": ASTM A395 and A536 ductile iron body and disc. Disc and body PPS coated. Mounted elastomer seal with stainless steel stem. Victaulic Series Victaulic Vic-300 AGS (300 psi max).
c. 2-1/2"–6": Copper tube dimensioned bronze body, EPDM encapsulated ductile iron disc, integrally cast stem. Victaulic Series 608.

2. Grooved end check valves shall be ASTM A395 and A536 ductile iron body, with stainless steel spring and shaft. Victaulic Series 716H and 716.
   a. 2" - 3": Ductile iron body with stainless steel disc, mounted elastomer seal, and nickel-plated seat.
   b. 4"-12": Black enamel coated ductile iron body, elastomer encapsulated ductile iron disc, with welded-in nickel seat.
   c. 14"-24": ASTM A395 ductile iron body, stainless steel disc, spring, and shaft, EPDM seat bonded to the valve body, AGS grooved ends. Victaulic Series W715.

M. All screwed-end globe valves shall be of the union bonnet type with renewable teflon discs.

N. All valves shall have their bonnets back-seated to provide for packing under pressure. All gate valves shall be of the solid tapered wedge type.

O. Drain valves shall be provided on tanks, receivers, risers and where they may be required or necessary, for draining the lines and equipment. Drain valves or plug cocks shall be provided at the low points for proper drainage. Cocks and valves shall be provided with threaded ends for those connections.

P. All valves up to 2 inches in diameter shall have screw ends, 2½ inches in diameter and over shall have flanged ends. Valves 2½" and larger which are non-rising stem, shall have position indicators.

Q. All bronze and iron valves shall be furnished with Teflon impregnated packing.

R. All handwheels shall be of malleable iron.

S. No Asbestos shall be used in construction of valves including the gaskets.

T. All valves shall be of type and number as specified below: For all services, except as otherwise noted.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>SIZE</th>
<th>NIBCO NO.</th>
<th>CRANE NO.</th>
<th>VICTAULIC NO.</th>
<th>JENKINS NO.</th>
<th>WALWORTH NO.</th>
<th>ABZ NO.</th>
<th>REMARKS</th>
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<tr>
<td>Gate Valve</td>
<td>2&quot; &amp; Smaller</td>
<td>T-134</td>
<td>428UB</td>
<td>810J</td>
<td>2</td>
<td>150 lb. WSP, Bronze</td>
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<td>2 ½” &amp; Larger</td>
<td>F-617-O</td>
<td>465 ½</td>
<td>454J</td>
<td>726F</td>
<td>Rising Stem 125 lb. WSP, Bronze Trimmed, Iron Body, OS&amp;Y</td>
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<td>TYPE</td>
<td>SIZE</td>
<td>TYPE NO.</td>
<td>CRANE NO.</td>
<td>VICTAULIC NO.</td>
<td>JENKINS NO.</td>
<td>WALWORTH NO.</td>
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<td>REMARKS</td>
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<td>Globe Valve</td>
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<td>T-275Y (Teflon)</td>
<td>14 ½ P</td>
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<td>78K</td>
<td>546P</td>
<td>237P 300 lb WSP, Bronze</td>
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<td>T275-B (Steam)</td>
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<td>T276-AP (SS Full-Plug)</td>
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<td>2 ½&quot; &amp; Larger</td>
<td>F-718B</td>
<td>351</td>
<td>788</td>
<td>789</td>
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<td>613C</td>
<td>906F 125 lb, WSP, Bronze Trimmed, Iron Body OS&amp;Y</td>
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<td>238P</td>
<td>300 lb, WSP, Bronze</td>
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<td>T375-B (Steam)</td>
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<td>F-818-B</td>
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<td>907F</td>
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<td>High Perf</td>
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<td>400 Series 300 psi Grooved DI, EPDM 285 psi Lug, DI, SS Disc, EPDM</td>
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<td>All Sizes</td>
<td>F-910 / w-910 (CI)</td>
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<td>----- 900 Williams-Hager Fig. 636, 125 WSP Semi-steel</td>
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<td>G-920-W (DI)</td>
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<td>716H</td>
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<td>Drain Valves</td>
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<td>T-113-HC</td>
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<td>200 lb. OWG, Non-rising stem, Hose end, Bronze with Bronze Cap &amp; Chain</td>
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<td>T-751-A F-721-A</td>
<td></td>
<td>W730</td>
<td></td>
<td></td>
<td></td>
<td>250 lb, WSP, Iron Body, 125 lb, WSP, Iron Body</td>
</tr>
</tbody>
</table>

U. Valves for radiation & gas service shall be as follows:

V. Hot Water Radiation Shut-off all sizes, 200 psi water, Sarco No. 740A with lock shield.
   Steam Radiation Shut-off - All sizes, Dunham-Bush Packless No.1240
   1. Fig. 1 Angle Pattern
   2. Fig. 3 straight thru
   3. Fig. 4 Lock shield type

W. Radiation Balancing - All sizes, 200 psi water, bronze, male union outlet, combination balancing, shut off and flow measuring, Sarco metered balance master valve, or approved equal. Provide model flow test kit.
X. **Gas System**
1. 2" & smaller, 125 WOG Crane No. 1228, square head cock
2. 2½" to 4"; 125 WOG Crane No. 324 Walworth #655
3. Alternatively, for gas service the Contractor may provide a UL/FM/CSA/NSF rated ball valve such as “RuBs.92”.

### 2.02 VALVES IN COPPER TUBING

#### A. Except where otherwise noted, all valves for use with copper tubing shall be as follows

<table>
<thead>
<tr>
<th>TYPE</th>
<th>SIZE</th>
<th>NIBCO NO</th>
<th>CRANE NO</th>
<th>VICTAULIC NO</th>
<th>JENKINS NO</th>
<th>WALWORTH NO</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate Valve</td>
<td>2&quot; &amp; Smaller</td>
<td>S-111</td>
<td>1320</td>
<td>----</td>
<td>----</td>
<td>125 lb WSP, Bronze</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3&quot; &amp; Smaller</td>
<td>S-134</td>
<td>----</td>
<td>----</td>
<td>1240</td>
<td>4-SJ</td>
<td>300 lb. Non-Shock</td>
</tr>
<tr>
<td></td>
<td>2 ½&quot; &amp; Larger</td>
<td>F-617-O</td>
<td>428</td>
<td>----</td>
<td>----</td>
<td>55</td>
<td>125 lb, WSP, Bronze trimmed, iron body, OS&amp;Y</td>
</tr>
<tr>
<td></td>
<td>3&quot; &amp; Smaller</td>
<td>S-211-Y</td>
<td>1310</td>
<td>----</td>
<td>----</td>
<td>125 lb WSP, bronze</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3&quot; &amp; Smaller</td>
<td>S-235-Y</td>
<td>----</td>
<td>----</td>
<td>1200</td>
<td>95-SJ</td>
<td>300 lb. Non-shock CW Bronze with solder joint adapter</td>
</tr>
<tr>
<td></td>
<td>2 ½&quot; &amp; Larger</td>
<td>F-718-B</td>
<td>14 ½ P</td>
<td>----</td>
<td>237P</td>
<td>125 lb, WSP, bronze trimmed, iron body OS&amp;Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3&quot; &amp; Smaller</td>
<td>S-311-Y</td>
<td>1311</td>
<td>----</td>
<td>----</td>
<td>125 lb WSP, Bronze</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3&quot; &amp; Smaller</td>
<td>S-335-Y</td>
<td>----</td>
<td>----</td>
<td>1200</td>
<td>----</td>
<td>300 lb. Non-shock CW Bronze with solder joint adapter</td>
</tr>
<tr>
<td></td>
<td>2 ½&quot; &amp; Larger</td>
<td>F-818-B</td>
<td>16 ½ P</td>
<td>----</td>
<td>----</td>
<td>125 lb WSP, bronze trimmed, iron body OS&amp;Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2&quot; &amp; Smaller</td>
<td>S-413-B</td>
<td>1303</td>
<td>----</td>
<td>----</td>
<td>406SJ</td>
<td>125 lb WSP, Bronze</td>
</tr>
<tr>
<td></td>
<td>3&quot; &amp; Smaller</td>
<td>S-433-B</td>
<td>----</td>
<td>----</td>
<td>1222</td>
<td>406</td>
<td>300 lb Non-shock CW Bronze with solder joint adapter</td>
</tr>
<tr>
<td></td>
<td>2 ½&quot; &amp; Larger</td>
<td>F-918-B</td>
<td>34</td>
<td>----</td>
<td>----</td>
<td>125 lb WSP, bronze trimmed, iron body OS&amp;Y</td>
<td></td>
</tr>
<tr>
<td>Swing Check</td>
<td>2½&quot; to 2&quot;</td>
<td>Tour and Anderson</td>
<td>786</td>
<td>787</td>
<td>78K</td>
<td></td>
<td>125 lb, WSP, bronze body, globe style, integral test, point, thrd or swt.</td>
</tr>
<tr>
<td>Balancing Valves</td>
<td>2 ½&quot; to 12&quot;</td>
<td>Tour and Anderson</td>
<td>786</td>
<td>787</td>
<td>78K</td>
<td></td>
<td>125 lb. WSP, iron body, non- rising stem, flg or grv</td>
</tr>
</tbody>
</table>

#### 2.03 REFRIGERANT VALVES

#### A. All refrigerant valves shall be silver brazed joint as follows:
5. Relief Valves - Angle type, brass, Henry type 52.
6. Gate Valves - All sizes: Globe Valves.
2.04 VALVE CONSTRUCTION

A. Piping less than 100 psi: 200# WOG Class, cast iron body.

B. Piping 100 psi to 250 psi: ANSI Class 150, carbon steel.
   1. 4" and larger: flanged, ANSI Class 150 rated.

C. Piping over 250 psi: ANSI Class 300, carbon steel body.
   1. Up to 2": screwed
   2. 2½" and larger: flanged, ANSI Class 300 rated.

2.05 BALANCING VALVES

A. All balancing valves shall be combination balancing, flow measuring and shut off valves. Valves shall be globe style design and shall have a position indicator and memory stop or locking device so that the valve can be closed without disturbing the setting and returned to the balanced position without further adjustment.

B. Valves shall be as manufactured by Tour and Andersson, Inc. or approved equal.

C. Nominal working pressure for the valves shall be 250 psig or greater at 250°F.

D. Provide portable flow measuring instruments which shall be turned over to the Owner at the completion of work.

E. Butterfly valves can be used for only shutoff valves and shall not be used for balancing.

F. Coil Hook-Up Assembly: Install with Tour & Andersson balancing valves 2" and smaller, Victaulic Series 799 or 79V Koil-Kit™ to complete terminal hookup at coil outlet and to reduce space requirements. Assembly shall consist of Victaulic Series 78U union port fitting, Series 78Y strainer/ball valve or Series 78T union/ball valve combination and flexible hoses.

2.06 BALL VALVES

A. Ball Valves up to 2½" may be used for all water services as an alternate to gate valves.

B. Ball valves shall be bronze body, bronze ball and stem, Teflon seats and seals threaded ends, 400 psig cold W.O.G. Worcester No. 411T-SE or equal. "APOLLO" 70 - 100 Series.

PART 3 - EXECUTION

3.01 INSPECTION

A. Contractor shall examine location where valves are to be installed and determine space conditions and notify architect in writing of conditions determined to proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
3.02 INSTALLATION

A. Install valves where shown or specified, in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that valves comply with requirements and serve intended purposes.

B. Install a manually operated bypass globe valve around all control valves (motorized or self-contained regulators).

C. Contractor is responsible for final valve orientation. Valves shall be installed in such a manner to avoid leakage through their stem seals, while still orienting valve handles to provide suitable accessibility and operability. Valve orientation shall be in compliance with the valve manufacturer’s installation instructions. Valve handle orientation shall be indicated on the piping shop drawings. Valves orientation and handles not shown on the piping shop drawings will be subject to possible removal and reorientation in the field based on the Engineer’s observations following the completion of construction.

D. Coordinate with other work as necessary to prevent interference of valves with other components of systems.

3.03 FIELD QUALITY CONTROL

A. Upon completion of installation of valves, test valves to demonstrate compliance with requirements. When possible, field correct malfunctioning valves, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected.

END OF SECTION 23 05 23
PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
A. This Section is coordinate with and complementary to the General Conditions and Supplementary General Conditions of the Work, wherever applicable to Mechanical Work.
B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

1.02 DESCRIPTION OF WORK
A. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all HVAC Specialties as shown on the Drawings and hereinafter specified.

1.03 QUALITY ASSURANCE
A. Firms regularly engaged in manufacturer of this equipment with characteristics and capacities required, whose products have been in satisfactory use in similar service for not less than ten (10) years.
B. Provide products produced by the manufacturers, which are listed in Section 23 05 12, entitled "Approved Manufacturers List".
C. Provide equipment whose performance under specified conditions is certified by the manufacturer.

1.04 SUBMITTALS
A. Refer to Section 01 31 46 - Special Requirements for Mechanical and Electrical Work and submit shop drawings.

1.05 COORDINATION
A. Refer to Section 01 31 46 - Special Requirements for Mechanical and Electrical Work.

1.06 GUARANTEE
A. Refer to Section 01 31 46 - Special Requirements for Mechanical and Electrical Work.
PART 2 - PRODUCTS

2.01 THERMOMETERS

A. Furnish and install, where indicated on the Drawings and where specified herein, separable well-type dial or 9" mercury adjustable angle type in glass stem, thermometers, Model 50 EI60E as manufactured by Ashcroft or approved equal.

B. All thermometers shall be installed in such a manner as to cause a minimum of restriction to flow in the pipes and so that they can easily be read from the floor.

C. Dial thermometers shall be 5 inch hermetically sealed, bimetal with stainless steel cases, antiparallax dials with raised jet black figures, stainless steel stems, and separable sockets (wells) unless otherwise specified.

D. Thermometers for duct mounting shall have union connections in lieu of separable wells.

E. Separable wells shall be stainless steel for use in steel pipe and brass for use in copper pipe. Separable wells shall be standard type for uninsulated pipe and lagging extension type of proper length for insulated pipe. Stem shall extend a minimum of 3½” into the fluid, or 75% of inside clear diameter for smaller size pipes.

F. The accuracy of all thermometers shall be within 1% of the full scale range.

G. All instrument wells for controls and indicators furnished by the temperature control manufacturer shall be installed under this Section.

H. Where conditions are such that thermometers would not be readable from the floor, remote bulb dial thermometers shall be mounted on panelboards. The thermometers shall be 5 inch dials and shall be vapor actuated. The thermometers shall have separable wells. Panel mounted thermometers shall be provided with an engraved nameplate mounted below each thermometer to identify its service. The nameplates shall be chrome plated with black filled letters.

I. A thermometer shall be installed in the hot water inlet and outlet of each heat exchanger. A thermometer shall be installed in the chilled water and condenser water inlet and outlet of each refrigeration machine. Additional thermometers shall be installed where indicated on the Drawings.

J. The scale range for the thermometers shall be as follows:

<table>
<thead>
<tr>
<th>Service</th>
<th>Temperature Range</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water</td>
<td>50°F to 250°F</td>
<td></td>
</tr>
</tbody>
</table>

2.02 PRESSURE GAUGES

A. Furnish and install where indicated on the Drawings and where specified herein, Model 1279 pressure gauges with phenolic casings as manufactured by Ashcroft. Process connection shall be ½” MNPT. Acceptable equals include Weiss Model LF4UGY1 or Noshok Model 660.
B. Gauges shall be liquid filled for systems under 150°F (chilled water, condenser water, fuel oil, etc.) and shall be dry for all heating systems (hot water, steam, condensate, etc.).

C. All gauges shall have black phenolic casings. The gauges shall have white faces with black filled engraved numerals and adjustable pointer. The diameter of the dial shall be 4½ inches. Gauges shall have brass bronzed brushed rotary type movement.

D. The accuracy of all gauges shall be within ½% of the scale range.

E. All gauges on water lines shall be fitted with filter type pressure snubbers consisting of ¾" dia. x ½" thick, micro metallic stainless steel filter, as manufactured by Operating and Maintenance Specialties or approved equal. All gauges on steam lines shall be fitted with siphon tubes.

F. A stainless steel bar stock block-and-bleed type needle valve shall be installed on the fluid side of each gauge, similar to Noshok Model Series 704MFS (size ½”). A stainless steel bar stock block-and-bleed type needle valve with a siphon tube shall be installed on the system side of each steam and HTHW gauge.

G. All gauges shall be installed so as to be easily readable from the floor. Where conditions are such that gauges on piping would not be readable from the floor, the gauges shall be installed on panelboards.

H. Panel mounted gauges shall be designed for flush mounting with back connections and shall be provided with an engraved nameplate mounted below each gauge to identify its service. The nameplates shall be chrome plated with black filled letters.

I. Differential pressure switches, pressure sensing pipe taps, furnished by temperature control manufacturers shall be installed under this Section.

J. Pressure gauges shall be installed in the suction and discharge of each hot water, chilled water, condenser water, condensate return, boiler feed and fuel oil pump. A pressure gauge shall be installed in the chilled water and condenser water inlet and outlet of each refrigeration machine. A pressure gauge shall be installed in the inlet and outlet of each heat exchanger and each air handler coil. A pressure gauge shall be installed at the inlet and outlet of each water, steam or fuel oil strainer. Additional pressure gauges shall be installed where indicated on the Drawings.

K. The scale range of pressure gauges shall be as follows:

<table>
<thead>
<tr>
<th>Service</th>
<th>Pressure Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water</td>
<td>0 to 100 PSIG</td>
</tr>
</tbody>
</table>

L. All other pressure gauges shall have a range at least twice the working pressure, but in no case less than 0 to 30 lbs.

2.03 MACHINERY GUARDS

A. Moving parts of machinery exposed to contact by personnel shall be guarded by barrier type which complies with OSHA.
B. Exposed moving parts such as belts and couplings shall have not less than \(\frac{3}{4}\)" No. 16 gauge metal guards with all edges rounded and gauge, material and construction shall be in accordance with OSHA standards - paragraphs 7173.3, 7173.5 and 7174.1. Guards shall have \(\frac{1}{4}\)" x \(\frac{1}{4}\)" x \(\frac{1}{8}\)" angle iron frame properly supported.

C. All machinery guards covering the ends of motor or equipment shafts shall have openings for the insertion of a tachometer. Machinery guards shall be painted with two coats of machinery gray enamel.

2.04 EXPANSION TANKS

A. Furnish and install as shown on the Drawings, EX-TROL Pressurized Diagram Type Expansion Tanks as manufactured by AMTROL INC. It shall be air precharged to the initial fill pressure of the system. It shall be suitable for a maximum working pressure of 125 psi and shall be furnished with ASME stamp and certification papers. It shall have a sealed-in elastomer diaphragm suitable for an operating temperature of 240°F. (EX-TROL to be furnished with saddles for horizontal installation).

2.05 EXPANSION JOINTS, BALL JOINTS, LOOPS, ANCHORS AND GUIDES

A. Provisions for expansion in piping mains, branches, and risers shall be made by the installation of offsets, expansion loops, or compensators as indicated on the Drawings and as required. Every 100'-0" horizontal steam and hot water piping shall have expansion loop and anchors. Minimum loop shall be 8'-0" by 6'-0" if not indicated on the Drawings.

B. All piping with loops or compensators shall be anchored so as to throw all expansion toward the loops or compensators.

C. Guides shall be installed on both sides of each expansion loop and compensator. Guides shall be Flexonics pipe alignment guides or approved equal. Anchors and guides shall be secured to beams, columns or concrete slabs.

D. Pipe hangers and rollers are not considered guides.

E. Provide 12" long guides for each expansion joint. Guides shall be located 3'-0" on each side of the expansion joints.

F. Furnish and install as shown on plans, or where necessary to absorb max. \(1\frac{3}{4}\)" expansion and max. \(\frac{1}{4}\)" contraction between two anchor points in copper lines, up to and including 2\(\frac{1}{2}\)", Flexonics Model HB Expansion Compensators having two-ply phosphor bronze bellows and brass shrouds and end fittings, as manufactured by Flexonics Division of Calumet and Heela, Inc., Bartlett, Illinois. All internal parts shall be of non-ferrous metals. Service pressure shall be external to the bellows. Compensators shall have internal guides extending the full length of the bellows travel. Compensators shall have internal positive anti-torque devices to prevent twist or torque on installation and shall have properly located positioning clip to insure installation of correct end-to-end dimension to allow full rated traverse. Compensator shall be for max. 125 psig. working pressure. Test pressure shall not exceed 175 psig.

G. Furnish and install as shown on plans, or where necessary to absorb max. \(1\frac{3}{4}\)" expansion and max. \(\frac{1}{4}\)" contraction between two anchor points in iron and steel pipe lines up to and including
2½", Flexonics Model II Expansion Compensators having two-ply stainless steel bellows and carbon steel shrouds and end fittings, as manufactured by Flexonics Division of Calumet & Heela, Inc., Bartlett, Illinois. Service pressure shall be external to the bellows. Compensators shall have properly located positioning clip to insure installation at correct end-to-end dimension to allow full rated traverse. Compensator shall be for Max. 150 psig. working pressure. Test pressure shall not exceed 200 psig.

H. Expansion joints in 3" and above piping shall be hydraulically formed bellows type with internal sleeves and external covers for insulation. Expansion joints, except where otherwise noted, shall be of the self-equalizing type having fully-contoured, cast iron equalizing rings.

I. Provide non-equalizing type expansion joints with internal sleeves on low pressure service (up to 15 psig including test pressure) such as diesel engine exhaust, or flexible cooling tower connections.

J. Manufacturer shall note on all submittal forms the resultant anchor loads due to pressure thrust and compressive forces at design conditions. Expansion joints shall be as manufactured by Flex-Hose, ADSCO, Zallea, Flexonic, or approved equal.

2.06 DRAFT GAUGES

A. Furnish and install at each filter, draft gauges for measuring the resistance of the air through the filters.

B. Each draft gauge shall be an inclined tube differential type for indoor units, equipped with a shut-off cock opening to atmosphere for checking zero setting, and with a shut-off cock in the lines to points where the draft is measured. The scale shall have a white background with heavy black divisions and figures; shall not be less than 8" long, and shall be graduated to read by hundredths of an inch up to resistances to be encountered. Each gauge shall be provided with a bubble level gauge and with screw adjustment for zero settings.

C. Draft gauge for rooftop units and outdoor unite shall be 2000 Series Magnehelic as made by Dwyer or approved equal. Gauges shall be provided complete with two static pressure tips case, fittings and means of mounting. Scale shall be as required. Set gauges to be easily readable from floor level. Gauges shall be of Dwyer make or approved equal.

2.07 AIR VENTS

A. In installing water piping systems and all equipment, carefully plan the actual installation in such a manner that high points and air pockets are kept to a minimum and are properly vented where they are unavoidable. All air elimination devices called for on the Drawings and in these Specifications shall be provided and properly installed. In addition, furnish and install all other air elimination devices which may be required due to job conditions. Assume responsibility for a proper, continuous and automatic air elimination to assure even and balanced distribution of water to all equipment.

B. Furnish and install an Armstrong No. 1 AV or Sarco 13W automatic air vent with test petcock at each high point in the water piping mains and where indicated on the Drawings. Furnish and install a 125 psig rated valve on the system side of each automatic air vent. Vents on hot water, dual temperature water and chilled water lines shall have Hoke Fig. No. PY-271 valves or
approved equal. Vents on all other water lines shall have Hoke Fig. No. RB-271 valves or approved equal.

C. Furnish and install manual air vents Hoffman No. 500 or approved equal, for all upfed radiation. Furnish and install a 125 psig rated ball valve on the system side of each manual air vent. Provide access to all air vents.

2.08 AIR SEPARATORS

A. Furnish and install the air separators for water system where indicated on the Drawings. The separators shall be Rolairtrol, as manufactured by Bell and Gossett or equal as approved by the Architect.

B. The units shall be of ASME construction and shall be stamped 125 psig W.P.

C. The units shall be furnished without integral strainers.

D. The units shall be installed in strict accordance with the manufacturer's recommendations.

E. The units shall be supported on 2" pipe legs and shall be provided with a ¾" drain gate or ball valve with hose end and cap.

2.09 V-BELT DRIVES

A. All V-belt drives furnished under this Section shall be Gates Rubber Co., Woods, or approved equal. Drives shall be designed with an overload factor of twice the fan brake horsepower but in no case less than 125% of motor horsepower rating. Machined cast iron pulleys shall be used. Manufacturer's shop drawings shall state actual transmission capacity of each drive. Provide companion sheaves for adjustable sheave drives. Companion sheaves shall be selected such that the individual belts shall not exceed a two degree misalignment of the groove center lines between the driving and driven sheaves. Sheaves shall be complete with flanges and locking devices. All sheaves shall be selected with a 1.5 minimum service factor.

B. Provide matching belts.

C. All motors up to 2½ HP shall have variable speed drives.

D. All motors 10 HP to 25 HP for speeds below 1000 RPM shall have variable speed drives.

E. Provide fixed drives above 1000 RPM for 10 to 25 HP and for all units above 25 HP.

2.10 STRAINERS FOR WATER SYSTEM

A. Furnish and install a full size Y-pattern strainer on the inlet of each control valve and each water pump, and where indicated on the Drawings. For pumps, the Contractor shall install either a Y-strainer or a suction diffuser with internal screened basket. Contractor shall not install both a Y-strainer and a suction diffuser.

B. The strainers shall be as manufactured by Spence, Sarco, Barnes and Jones, Elliott, Crane or Mueller.
C. All strainers, except where otherwise noted, shall have bronze body up to 2½", semi-steel above 2½", rated at 125 psig for all systems with 50 psig max. pressure and 250 psig for all others. Strainers 2 inch diameter and smaller shall have screwed ends. Strainers 2½ inch diameter and larger shall have flanged ends.

D. All strainers shall have removable cylindrical or conical screens of brass construction. They shall be designed to allow blowing out of accumulated sediment and to facilitate removal and replacement of the screen without disconnecting the main piping.

E. Screens for water 1/16" for 3" inclusive, ⅛" for 4" and above.

F. An approved blow-out connection with gate valve shall be made to each strainer. The valves shall be located not higher than 8 feet above the floor. All drain connections shall be piped to floor drains.

2.11 FLANGES FOR ORIFICE PLATES

A. The automatic control manufacturer shall furnish orifice plates for high temperature hot water lines as specified in the article of this Section entitled "Automatic Controls".

B. Install the orifice plates and furnish and install the companion flanges.

C. The orifice plates shall be installed in strict accordance with the manufacturer's recommendations.

D. Straightening vanes shall be installed if required by the automatic control manufacturer.

2.12 REDUCING AND SAFETY VALVES FOR WATER SYSTEM

A. Furnish and install pressure reducing and safety valves for makeup water systems and where indicated on the drawings.

B. The reducing valve shall be Model 7 pressure reducing valve with field adjustable setting as manufactured by Bell & Gossett or equal as approved by the Architect.

C. The safety valves shall be of size and capacity as indicated on the Drawings. The valves shall be made by Bell and Gossett or approved equal and shall have 150 pound raised face flange on the inlet and discharge for all sizes 2½" and above 2" and below shall be screwed.

D. The safety valves shall be steel valves with stainless steel trim. The bonnet shall be enclosed and equipped with a packed lifting lever. The spring shall be carbon steel rated for 450° F.

E. The vertical discharge line from the safety valves shall be installed as close to the safety valves as possible and piped to drain.

2.13 PRESSURE AND TEMPERATURE TEST STATIONS

A. Furnish and install in each supply and return runout to each reheat coil and where indicated on the Drawings, a ¼" MPT fitting to receive either a temperature or pressure probe ⅛" OD. Fitting shall be stainless steel with valve core of Nordel (Max. 275°F), fitted with a color coded and marked cap with gasket, and shall be rated at 1000 psig.
B. In addition, the installing Contractor shall supply the Owner with six pressure gauge adapters with \( \frac{1}{8}'' \) OD probe and 6 five inch stem pocket testing thermometers; 25-125°F for chilled water and six 0-220°F for hot water.

C. Provide one pressure and temperature test kit consisting of one 0-60 PSI, water pressure gauge and one 0-30 psi water pressure gauge each with No. 500 gauge adapter attached, a 25-125°F pocket testing thermometer, a 0.220 F pocket test thermometer, a No. 500 gauge adapter, and a protective carrying case. Provide one additional 0-60 psi pressure gauge and one additional 0 to 30 psi pressure gauge.

D. Test kit shall be used by the Balancing Contractor to balance the systems and then it shall be turned over to the Owner.

E. Test stations and test kit shall be manufactured by Paterson Engineering Company, Inc. or approved equal.

2.14 REFRIGERATION ACCESSORIES

A. Refrigerant Filter-Dryer: Provide, refrigerant filter-dryers. Refrigerant filter-dryers shall be replaceable core "Catch All" type, as manufactured by Sporlan Valve Company.

B. Moisture and Liquid Indicator: Provide combination liquid and moisture indicators type "See All", as manufactured by Sporlan Valve Company.

C. Refrigerant Strainers: Provide Refrigerant Strainers. Strainers shall be as manufactured by Henry Valve Company, Type 895.

D. Thermal Expansion Valves: Provide Thermal Expansion Valves. Thermal expansion valves shall be Type "MVE-G", as manufactured by Sporlan Valve Company, or approved equal, with external equalizer and remote bulb with refrigerant 22 charge.
   1. The Contractor shall submit manufacturer rating tables and/or selection charts for approval.

E. Liquid Line Solenoid Valves: Provide Liquid Line Solenoid Valves. Valves to have stainless steel diaphragm-welded and lead-proof construction, replaceable thermostatic element and tight seating. Valve shall be as manufactured by Sporlan Valve Company or approved equal.

F. Flexible Pipe Connections: Provide flexible pipe connections. Flexible pipe connectors to be all bronze construction, metal braided type suitable for Refrigerant 22.

2.15 EVACUATION OF REFRIGERATION PIPING

A. When testing of refrigerant piping is completed as specified hereinafter, blow off the pressure in the system to atmosphere and provide final evacuation. Provide a vacuum pump capable of pulling vacuum of at least 1 mm Hg. absolute. Use a Zimmerli gauge to read vacuum. Remove all moisture from the system. Operate the vacuum pump until a vacuum of 2.5 mm Hg. is achieved.

B. When the system is evacuated, break the vacuum with oil pumped, dry nitrogen, open the compressor suction and discharge service valves and re-evacuate the system to 2.5 mm Hg.
absolute. Stop vacuum pump and allow system to stand under a vacuum a minimum of 12 hours. If no noticeable rise in pressure has taken place after 12 hours, the system shall be charged.

2.16 LEL AND CO GAS DETECTION SYSTEM

A. A natural gas (LEL) and carbon monoxide (CO) detection system shall be provided for the boiler room. The system shall consist of a single control panel per mechanical room, one (1) remotely mounted LEL sensor per room, and one (1) remotely mounted CO sensor per room. The system shall measure and display gas concentrations and provide outputs for alarm and HVAC interlocks as described herein.

B. Provide breakglass shutoff switch located adjacent to the boiler room door to shut down the boiler when activated.

C. Sensor Requirements
1. The gas sensors shall be the infrared type, with detection range of 0-100% LEL and 3-wire 4-20 mA output. The sensor’s IR source shall have a 10 year warranty. The transmitter shall have built-in display with non-intrusive calibration, and shall be rated Class I, Div 1, Groups B, C and D. The sensors shall be dual-condulet type, whereby the sensor housing and transmitter housings are separate, with sensor to be mounted at ceiling and transmitter to be mounted at eye-level on a nearby wall or column.

2. The CO sensors shall be the electrochemical type, with detection range of 0-100 PPM and 3-wire 4-20 mA output. Typical sensor lifespan shall be 2 years. The sensor shall be rated Class I, Div 1, Groups A, B, C and D.

3. The Contractor shall install the sensors per the manufacturer’s guidelines, and shall furnish and install the necessary signal cable in conduit between the sensor, transmitter, and the control panel. Remote calibration tubing shall also be installed between the gas sensors at the ceiling and their respective transmitters at eye-level.

D. Control Panel Requirements:
1. The control panel shall be wall mount type, with NEMA 4X rating, and shall operate on 120 VAC, 50/60 Hz power.

2. A common LCD shall display the real-time gas values for all remote sensors simultaneously.

3. Visual Alarm Indicators – each channel shall have separate indicating lights for warning, alarm, and fault conditions.

4. Alarm Set Point Levels – Two separate alarm set point levels shall be provided for each channel (warning and alarm). Each set point shall be independently adjustable for any value in the detection readout range.

5. Eight fully configurable relays shall be provided, and shall be assignable to any set point or group of set points. Alarm relays shall be field selectable as latching or non-latching and normally energized or normally de-energized. All configurable relays shall be SPDT with contacts rated for 5 amps at 120 VAC.

6. The panel shall provide a common warning relay, common alarm relay, (2) common horn relays, and (2) common fault relays. All common relays shall be SPDT with contacts rated for 5 amps at 120 VAC.

7. Audible Alarm - A 75 db audible buzzer shall be integral to the panel. A front-mounted acknowledge button shall allow the horn to be silenced during active alarm events.

8. Visual Alarm – a red strobe light shall be installed on the top of the control panel enclosure.
E. Ventilation and Alarm Interconnects
1. Upon any detection of gas above 20% LEL or CO above 25 PPM, alarms shall be sent to the BMS.
2. Upon any detection of gas above 30% LEL or CO above 150 PPM, all gas-fired equipment shall automatically shut down and audible and visual alarms shall be activated at the panel at the BMS. The visual shall be latching and shall not deactivate until all sensors are below 30% LEL or 150 PPM CO and building personnel reset the panel via the front-mounted reset button.
3. The panel shall provide (3) additional signals for connection to the BMS: high LEL, high CO, and system fault.

F. Calibration Accessories
1. Contractor shall furnish a calibration kit with sufficient test gas for initial system start-up as well as semi-annual calibrations for three years following initial start-up. Kit shall include any accessories required for interfacing with the sensors.

G. Start-Up and Training Service
1. Contractor shall provide the services of a factory representative for the purpose of initial start-up, calibration, and training of the Owner’s personnel in proper system operation and maintenance.

H. The system shall be the Mine Safety Appliances Co. Gasgard XL panel with Ultima X gas sensors, as represented by Vanguard Controls Inc. at (973)691-2246.

PART 3 - EXECUTION

3.01 INSPECTION
A. Contractor shall examine location where these specialties are to be installed and determine space conditions and notify Architect in writing of conditions detrimental to proper and timely completion of the work.
B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION
A. Install HVAC Specialties where shown, in accordance with manufacturer's written instructions and with recognized industry practices, to ensure that HVAC Specialties comply with requirements and serve intended purposes.
B. Coordinate with other work as necessary to interface installation of HVAC Specialties with other components of systems.

3.03 FIELD QUALITY CONTROL
A. Upon completion of installation of HVAC Specialties, test HVAC Specialties to demonstrate compliance with requirements. When possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected.
END OF SECTION 23 05 80
SECTION 23 05 93
TESTING AND BALANCING

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. This Section is coordinate with and complementary to the General Conditions and Supplementary General Conditions of the Work, wherever applicable to Mechanical Work.

B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

1.02 DESCRIPTION OF WORK

A. All piping and equipment shall be tested. Labor including standby electrician, materials, instruments and power required for testing shall be furnished unless otherwise indicated under the particular Section of the Specification.

B. Tests shall be performed in the presence of and to the satisfaction of the Architect and such other parties as may have legal jurisdiction.

C. In no case shall piping, equipment, or accessories be subjected to pressure exceeding their ratings.

D. All defective work shall be promptly repaired or replaced and the tests shall be repeated until the particular system and component parts thereof receive the approval of the Architect.

E. Any damage resulting from tests to any and all trades shall be repaired and damaged materials replaced, all to the satisfaction of the Architect.

F. The duration of tests shall be as determined by all authorities having jurisdiction, but in no case less than the time prescribed below.

G. Equipment and systems which normally operate during certain seasons of the year shall be tested during the appropriate season. Tests shall be performed on individual equipment, systems, and their controls. Whenever the equipment or system under test is interrelated and depends upon the operation of other equipment, systems and controls for proper operation, functioning and performance, the latter shall be operated simultaneously with the equipment or system being tested.

H. All fans and duct systems shall be completely balanced by the adjustment of sheaves, dampers, registers and other volume and diverting control devices, to obtain the air quantities indicated on the design drawings. Replace sheaves if required to meet design conditions.

I. All pumps and piping systems shall be completely balanced by the adjustment of plug cocks, globe valves or other control devices, to obtain flow quantities indicated on the design drawings.

J. Tests shall be performed in presence and to satisfaction of Architect, and such other parties as may have legal jurisdiction. Submit completed reports for approval. If air and water balancing
cannot be verified in two, four hour tests (total of eight hours) the Contractor shall pay the Architect or his representative for any additional time spent to balance the system.

1.03 QUALITY ASSURANCE

A. Prior to installation of the mechanical systems, engage the services of an independent air and water balancing firm that shall be subject to the approval of the Architect. The firm shall have no affiliation with a mechanical contracting or sheetmetal company. Balancing and testing company shall be a member of the Associated Air Balance Council (AABC), National Environmental Balance Bureau (NEBB) or Testing, Adjusting and Balancing Bureau (TABB). The balancing firm shall have at least one member of its full time staff who is a licensed professional engineer who shall supervise the balancing work. Prior to balancing, a list of instruments to be used shall be submitted to the Architect. All instruments shall be calibrated within six months before tests.

B. Prior to installation of the mechanical systems, the licensed Professional Engineer for the Balancing and Testing Company shall review the contract documents to confirm that all balancing devices are provided to allow for complete balancing of the air and water systems for the project. The Balancing and Testing Company shall submit a letter confirming that they have performed this review and identifying any issues.

After the mechanical systems are installed and before the systems are enclosed behind walls and ceilings, the PE for the Balancing and Testing Company shall perform a review of the installation to verify that the required balancing devices have been installed and that the systems are ready for balancing. The Balancing and Testing Company shall submit a letter confirming that the inspection has been performed and that the system is ready for balancing.

Both letters shall be signed and sealed by the Balancing and Testing Company’s Professional Engineer.

C. When all specified testing and balancing procedures have been completed, a written report shall be submitted to the Architect for review. The report shall be tabulated in standard AABC/TABB format. As part of the Architect's review process, the accuracy of the balancing report shall be field spot checked on a random basis, with the assistance of the balancing firm's project supervisor. The HVAC Contractor shall reimburse the Architect for all time spent in excess of eight working hours, to demonstrate the accuracy of the balancing report.

1.04 SUBMITTALS

A. Refer to Section 01 31 46 "Special Requirements for Mechanical and Electrical Work". Submit all test and balancing reports as described hereinafter.
PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 FIELD TEST OF PIPING

A. During construction properly cap or plug all lines to prevent the entrance of sand, dirt, etc. The system of piping shall be blown through wherever necessary after completion (for the purpose of removing grit, dirt, sand, etc., from all equipment and piping), for as long a time as is required to thoroughly clean the apparatus.

B. All piping shall be tested as hereinafter specified. Tests shall be made after erection and before covering is applied or piping painted or concealed, and as sections of mains and groups of risers are completed. The extent of the work completed before pressure tests are made shall be determined by the Architect.

C. All piping, unless otherwise specified, shall be tested to a hydrostatic pressure at least 1-1/2 times the maximum designed working pressure (but not less than 50 lbs. per square inch) for a sufficiently long time to detect all leaks and defects; and after testing shall be made tight in the most approved manner. Tests shall be repeated once after leaks and defects have been repaired. When automatic control valves, equipment and similar devices which are incapable of withstanding test pressures applied to piping, such devices shall be removed, or otherwise protected during tests. After approval of such tests, devices shall be installed and tested with operating medium to operating pressures. The following shall be tested for four consecutive hours and proved tight. Leaks shall be remedied by replacing defective work.

<table>
<thead>
<tr>
<th>Hydrostatic Item</th>
<th>Field Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overflow and drain</td>
<td>50 psi</td>
</tr>
<tr>
<td>Cold Water (domestic)</td>
<td>100 psi</td>
</tr>
<tr>
<td>Hot water heating</td>
<td>100 psi</td>
</tr>
<tr>
<td>Gas</td>
<td>50 psi</td>
</tr>
<tr>
<td>Gas Vent</td>
<td>50 psi</td>
</tr>
<tr>
<td>Chemical Treatment</td>
<td>-Hot water</td>
</tr>
<tr>
<td></td>
<td>100 psi</td>
</tr>
<tr>
<td>Vent</td>
<td>-Water discharge</td>
</tr>
<tr>
<td></td>
<td>100 psi</td>
</tr>
</tbody>
</table>

D. Leaks appearing during the various pressure tests shall be corrected by replacing all defective materials or welds and subsequent tests shall be made until the piping is found perfect. Caulking of screwed joints or pending of welds is prohibited. Wherever it is necessary to cut out a weld and the ends of the pipe cannot be conveniently brought together, then a short piece of pipe shall be fitted in and welded as approved by the Architect.

E. Provide all other tests required by the Building Department, Fire Department and all other Authorities Having Jurisdiction (AHJ).

3.02 RUNNING TEST OF PIPING SYSTEMS

A. When directed, any section of the work, after it has been completed and otherwise satisfactorily tested, shall be put in actual operation and operated for a period of two (2) days of 24 hours each,
during which time any defects which may appear shall be remedied and any adjustment which may be necessary shall be made.

B. During the time of the tests, repack all valves, make all adjustments and otherwise put the apparatus in perfect condition for operation, and instruct the Owner's representative in the use and management of the apparatus.

3.03 TESTING, EVACUATION AND CHARGING OF REFRIGERATION PIPING

A. The Contractor shall notify the owner 24 hours in advance of any test so that the owner and/or manufacturer's representative may be present for the test if desired.

B. When the refrigeration connections have been completed, the system shall be tested at 240 psig on the low pressure side and 430 psig on the high pressure side or in accordance with the recommendation of the refrigerant equipment manufacturer. Liquid refrigerant shall be charged into the system to raise the pressure to 35 psig, and dry nitrogen added to obtain the desired test pressure. Leak testing shall be performed with an electronic leak detector. Refrigeration piping will not be acceptable unless it is gas tight. If any leaks are found, isolate the defective area, discharge the gas and repair the leaks, and then repeat the test.

C. The system shall be evacuated with a vacuum pump specifically manufactured for vacuum duty, having a capability of pulling a vacuum of 50 microns or less. The pump should be connected to both the low and the high side evacuation valves with copper or high vacuum hoses. The compressor service valves should remain closed. A high vacuum gauge capable of registering pressure in microns should be attached to the system for pressure readings. To check the system pressure, a hand valve must be provided between the pressure gauge and the vacuum pump which can be closed to isolate the system and check the pressure.

D. Evacuate each system to an absolute pressure not exceeding 1,500 microns. Break the vacuum to 2 psig with the refrigerant to be used in the system. Repeat the evacuation process, again breaking the vacuum with refrigerant. Install a drier of the required size in the liquid line, open the compressor suction and discharge valves, and evacuate to an absolute pressure not exceeding 500 microns. Leave the vacuum pump running for not less than two hours without interruption. Raise the system pressure to 2 psig with refrigerant, and remove the vacuum pump.

E. Refrigerant shall be charged directly from the original drums through a combination filter-drier each drier may be used for a maximum of three cylinders of refrigerant, and then must be replaced with a fresh drier charge the system by means of a charging fitting in the liquid line. Weight the refrigerant drum before charging so that an accurate record can be kept of the weight of refrigerant put in the system. If refrigerant is added to the system through the suction side of the compressor charge in vapor form only.

F. Condensing units will be delivered to the job with sufficient oil for the average installation. Check all compressors for proper oil level, and if necessary add sufficient oil to bring the level to the center of the crankcase sight glass. Use only the refrigeration oil recommended by the condensing unit manufacturer all oil must be delivered to the job in factory sealed, unopened containers.
G. Refrigeration piping shall be tested in accordance with the recommendations of the refrigeration equipment manufacturer or in the following sequence in the absence of manufacturer requirements, for a period of 24 hours.

- High Side - Nitrogen at 300 psi
- Low Side - Nitrogen at 150 psi
- Entire System - Refrigerant at 5 psi

H. No visible leaks, losses in pressure or increase in vacuum occur during test period.

3.04 HOT WATER BOILER TEST

A. After the hot water boiler has been installed and before it is started, it shall be hydrostatically tested as required by the ASME Power Boiler Test Code and the pressure shall be maintained at least one hour with no visible leaks or loss in pressure. All air shall be expelled before hydrostatic test pressure is applied. During the test period, the hot water boiler shall be continually examined for leaks. The test shall be performed on the hot water boiler under the supervision of the manufacturer of the hot water boiler. Should any leaks of a major nature be encountered during the testing of the hot water boiler, the tests shall be discontinued and the Owner advised immediately.

B. After the hot water boiler has satisfactorily passed the hydrostatic tests, it shall be cleaned in accordance with the recommendations of the manufacturer. After cleaning, all strainers shall be cleaned. Following the strainer cleaning, the hot water boiler shall be filled with water, vented and started.

C. Upon completion of the installation of the hot water boiler and allied equipment, under the supervision of the manufacturer, run a 16 hour test on the boiler in which all performance data shall be verified and all adjustments including fuel and air ratio and balancing of the water circulation shall be performed. The performance test shall be run in accordance with the latest ASME procedures for the Power Boiler Test Code. The test to be performed shall follow the following loads:

1. Four hours at 25% load
2. Four hours at 50% load
3. Eight hours at 100% load

D. The boiler manufacturer shall temporarily provide all test instruments inclusive of the oil meter that may be required to supplement the instruments furnished under this Contract in order to completely evaluate the performance test.

E. Upon completion of the load performance tests, the hot water boiler manufacturer shall submit the complete calculations and analysis of his data to the Owner for his files and future reference.

3.05 EQUIPMENT TEST

A. Demonstrate that all equipment and apparatus fulfill the requirements of the Specifications and that all equipment shall be operated and tested for rated capacities and specified characteristics. Voltage and amperage readings shall be taken on all electric motors.
B. Operate air handlers and fans for 40 hours and demonstrate fans operating at maximum capacity, with all variable volume dampers to be at the full open position.

3.06 FIRE DAMPER AND FIRE SMOKE DAMPER TEST
A. Under this section test each and every fire damper by removing the fusible link to demonstrate that the damper properly closed.
B. Under this section test each and every fire smoke damper by removing the fusible link or alternately applying heat to the heat detector for dampers utilizing heat detectors) to demonstrate full closure. Also demonstrate that the damper opens and closes properly under automatic control through the operator.
C. After the successful completion of such tests reinstall fusible links and reset heat detectors.
D. All such tests shall be conducted under direction of a New Jersey Professional Engineer retained by the Contractor.

3.07 TEST PREPARATION AND PROCEDURE
A. On initial startup, prior to any tests, check the rotation and running amperage of all fan and pump motors to prevent damage to equipment by overload.
B. Final balancing must be done with all systems completely installed and operating, and after the automatic temperature controls have had their final adjustment.
C. New, clean filters must be installed in all supply systems prior to balancing.
D. All water systems shall be completely filled and vented, and all strainers cleaned prior to balancing. Inspect expansion tanks for proper water level and operating of makeup water valves.
E. All main supply air ducts shall be traversed, using a pitot tube and manometer. The manometer shall be calibrated to read two significant figures in all velocity pressure ranges. Duct traverses shall be conducted using the log-Tchebycheff method. The equal area method is not acceptable.
F. A main duct is defined as either of the following:
   1. A duct serving five or more outlets.
   2. A duct serving two or more branch ducts.
   3. A duct serving a reheat coil.
   4. A duct emanating from a fan discharge or plenum and terminating at one or more outlets.
G. The intent of this operation is to measure by traverse the total air quantity supplied by the fan and to verify the distribution of air to zones.
H. Submit data in support of all supply fan deliveries by the following four methods:
   1. By summation of the air quantity readings at all outlets.
   2. By duct traverse of main supply ducts and directly at the air handler or fan discharge.
   3. By a rotating vane traverse across a filter or coil bank.
4. By plotting RPM and static pressure readings on the fan curve. Air density corrections
must be indicated.

I. For return air and exhaust fans, the rotating vane traverse is not required.

J. Inspect all fan scrolls and remove objects or debris. Inspect all coils and remove debris or
obstructions. Verify that all fire dampers are open.

K. The supply air systems shall be completely balanced prior to the final balancing of the water
systems.

L. Upon completion of all air and water balancing, all duct dampers, plug valves and other throttling
devices shall be permanently marked in the final adjusted position.

3.08 AIR BALANCE

A. Record the following design requirements for all fans and fan motors from the approved shop
drawings.
1. Air quantities - CFM
2. Approximate fan speed - RPM
3. Fan static pressure (total or external) - inches of water.
4. Maximum tip speed - FPM
5. Outlet velocity - FPM
6. Fan brake horsepower
7. Motor horsepower
8. Volts, phases, cycles and amps at design conditions.

B. Record the following data from all fans and fan motors installed at the project:
1. Manufacturer, model and size
2. Motor horsepower, service factor and RPM
3. Volts, phases, cycles and full load amps
4. Motor starter and heaters size
5. Equipment location

C. All fans and duct systems shall be completely balanced by the adjustment of sheaves, dampers,
registers and other volume and diverting control devices, to obtain the air quantities indicated on
the Drawings. Outside air and return air modulating dampers shall be adjusted to admit the
specified quantities of air under all cycles of operation. All final adjusted air quantities shall be
within 10% of the design requirements. Replace sheaves if required to meet design conditions.

D. Record the following test data for all fans and motors installed at the Project at final balanced
conditions:
1. Fan speed RPM.
2. Fan static pressure (external and total) inches of water.
3. Static pressure drop across all filters, dampers, coils and other items in the supply fan
casings.
4. Motor operating amps. (Measure, record and report all motor amps at minimum outside air
volume and at maximum outside air volume.) This requirement applies to both constant
volume and variable air volume systems where economizers are present.
5. Actual voltage
6. Fan CFM
7. Calculated brake horsepower.

E. Submit single line diagrams of all duct systems indicating all terminal outlets identified by number. Data sheets shall list all such outlets denoted by the same numbers, including the outlet's size, "K" factor, location, CFM and jet velocity.

F. Submit this data for all supply, return and exhaust air systems.

G. Adjust the outside air, relief air and return air dampers to admit the required amounts of outside air. Record and submit outside air flow measurement and the outside, return and mixed air temperatures for both cycles after final adjustments.

H. Air balancing shall be performed with filters partially blocked to simulate a pressure drop across the filters equal to that midway between the clean and the dirty condition.

3.09 VARIABLE AIR VOLUME SYSTEM

A. Check and record the following items on the supply and return fans:
1. Correct fan rotation.
2. Filter condition (clean or dirty).
3. Cooling coil condition (dry or wet).

B. Set the controls for the supply and return fans to operate at maximum capacity and for all variable volume dampers to be at the full open position.

C. Set the system up to operate with maximum return air and minimum outside air.

D. The following preliminary data should be obtained and recorded at the supply and return fans:
1. Fan and motor RPM.
2. Motor and current voltage.
3. Fan, coils and filter statics.
4. Nameplate data on the fans and motors.
5. Motor sheave, fan pulley and belt sizes.

E. Traverse the main supply ducts and return ducts to determine CFM deliveries of the fans.

F. Set the system to operate at 100% outside air and check the motor amperage. The motor amperage should remain relatively constant indicating no change in total air flow. If a change in flow does occur, adjust outside air, return air, and relief air dampers accordingly. Set enough variable volume controllers throughout the building to maximum in order to simulate a maximum load on the fan.

G. Measure the system duct static pressure at selected points throughout the system. Monitoring points shall be in those duct runs which are of the longest equivalent length (greatest friction loss). Monitor these points during the adjusting and balancing procedures to assure proper inlet static pressure is being maintained to the variable volume units.
H. Adjust the return fan to approximately 5% above design CFM and the supply fan to either 5% above design or to the point where the static pressure at the end of each branch is at required static pressure, whichever condition is reached first.
   1. If the fan is adjusted to obtain the minimum static pressure, then it may be necessary to readjust the fan during the balancing as the static pressure will decrease as the constant volume controller deliveries are increased.

I. Make preliminary outlet readings and balance the outlets to design CFM and record all readings.

J. Individually set the controls for each variable volume damper to comply with correct sequence of operation.

K. Check the variable volume controller for design delivery.
   1. Check all the units, but make no adjustments. Report the results.
   2. If check passes, then proceed with balancing.
   3. Do all setting and adjusting required.
   4. When necessary corrections have been made, a verification test will be required.

L. Adjust the outlets for design delivery.

M. The following final data should be obtained and recorded at the supply and return fans:
   1. Fan and motor RPM.
   2. Motor current and voltage.
   3. Fans, coils and filter statics
   4. Approximate motor sheave setting

N. Check the following controls:
   1. Economizer system function, calibration and damper synchronization.
   2. Face and bypass dampers function and calibration, if any.
   3. High temperature limit shutoff function and calibration, if any.
   4. Low temperature limit shutoff function and calibration, if any.

O. Set all controls to their normal set points and allow all controllers to reach a satisfied state.

P. Measure the mixed air plenum static pressure to verify that the return fan capacity controller is functioning properly. The static pressure in the plenum should be within .05” W.C. of the final balance condition.

Q. Walk through the building and listen for noise generated by the air distribution system. Excessive noise should be reported.

R. All above recorded items and readings shall be submitted to the Architect.

S. Balance all induction units by primary air nozzle pressure. Record the following data in addition to the design requirements for each unit.
   1. Unit size and location.
   2. Final nozzle pressure - inches of water.
   3. Water entering and leaving temperature and pressure drop through coil at full flow.
   4. Primary air temperature, room temperature and supply air temperature.
T. Adjust and test all terminal boxes, mixing boxes and their controls to deliver the required air quantities. Record the following data in addition to the design requirements for each unit:
1. Box size and location.
2. Air temperatures in the hot duct and cold duct inlets for cooling and full heating.
3. Static, velocity and total pressures in hot duct and cold duct inlets for full cooling and full heating.

3.10 ADDITIONAL REQUIREMENTS

A. Replacement of adjustable pulleys, additional balancing dampers, additional fan belts, pressure taps and fittings, hydronic balancing valves and any other devices or equipment required to effect proper testing, adjusting and balancing shall be provided at no additional cost to the Owner.

3.11 WATER BALANCE

A. Record the following design requirements for all pumps and pump motors from the approved shop drawings:
1. Water quantity - GPM
2. Total head - feet of water
3. Pump speed - RPM
4. Impeller size
5. NPSH (if required)
6. Motor horsepower
7. Volts, phases, cycles and amps at design conditions

B. Record the following data from all pumps motors installed at the project:
1. Manufacturer, model and size.
2. Impeller size
3. Motor horsepower, service factor and RPM
4. Volts, phases, cycles and full load amps
5. Motor starter and heaters size
6. Equipment location

C. All pumps and piping systems shall be completely balanced by the adjustment of plug cocks, globe valves or other control devices, to obtain the flow quantities indicated on the Drawings. Balancing shall be done with all controls set for full flow through coils. All automatic throttling valves shall be in the full-open position. All automatic three-way valves shall have the bypass port closed.

D. Record the following test data for all pumps and pump motors installed at the Project:
1. Pump speed - RPM
2. Total head at shut-off and dead-end discharge - feet of water. (Plot this value on pump curve as a verification of impeller size.)
3. Suction, discharge and total head at final adjusted flow - feet of water.

E. Balance the water flow through all coils, convertors, cabinet heaters, heat exchangers, unit heaters, fan coil units, etc., in accordance with design requirements.
F. Flow shall be balanced through all equipment and coils by means of balancing and flow measuring valves provided. In addition, pressure drop shall be measured and curves obtained from the various manufacturers indicating the relationship between flow and pressure drop through the coils and equipment. Readings shall be taken on calibrated test gauges. Submit curves with the final report. Final report shall document all flow and pressure drop measurements.

G. Balance pumps to their design flow rate, within 100% and 110% of design, so long as pump and motor rating permits. Balance flow through all coils and terminal units to ±10% of design flow rate.

H. Upon completion of the water balance, reconcile the total heat transfer through all coils by recording the entering and leaving water temperatures and the entering and leaving air dry bulb and wet bulb temperatures.

I. Upon completion of balancing, adjust all differential bypasses and three-way valve bypasses for the same pressure drop or full bypass as on full flow.

END OF SECTION 23 05 93
PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. This Section is coordinate with and complementary to the General Conditions and Supplementary General Conditions of the Work, wherever applicable to Mechanical Work.

B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

1.02 DESCRIPTION OF WORK

A. The work includes furnishing and installing all labor, materials, equipment, accessories and services necessary to provide Piping, Ductwork and Equipment Insulation installation, which is complete in every respect and of the composition and quality as shown on the Drawings and hereinafter specified.

1.03 PIPE INSULATION

A. The following pipes shall not be insulated. Insulate all other piping:
   1. Unions.
   2. Automatic air vent drain pipes.
   3. Drain piping from safety relief valve drip pan elbows and steam exhaust heads.
   4. Piping under radiation cover.
   5. Outside portion of emergency generator exhaust pipe.
   6. Refrigerant liquid and outdoor portions of refrigerant hot gas piping except where otherwise noted.

1.04 DUCTWORK INSULATION

A. Insulate all ductwork except the following portions of ductwork:
   1. Ducts provided with sound absorptive lining (except where located outdoors) may have external insulation thickness decreased provided overall insulation R-value internal plus external complies with R-value specified herein.
   2. All exhaust ductwork, except where otherwise noted.
   3. Return air ductwork passing through air conditioned space and/or hung ceiling of air conditioned space, except in single story buildings and ducts in ceiling of uppermost floor or in attic space, where all return air ducts must be insulated.
   4. Return air ductwork for heating and ventilating systems, where return air ducts pass through heated areas.
   5. Supply ducts above hung ceilings where space above hung ceilings is used for return air plenum, except below roof.

1.05 QUALITY ASSURANCE

A. "Installer": A firm with at least ten years successful installation experience on projects with piping and ductwork insulation similar to that required for this project.
B. All insulation shall have composite (including insulation jacket or facing and adhesive) fire and smoke hazard ratings as tested by procedure ASTM E-84, NFPA 255 and UL 723 not exceeding:
   1. Flame Spread 25
   2. Smoke Developed 50
   3. Fuel Contributed 50

C. Accessories such as adhesives, mastics, cements, tapes and cloths for fittings shall have component ratings as listed above. All products shall bear UL labels indicating the above are not exceeded.

D. Provide certifications or other data as necessary to show compliance with these Specifications and governing regulations. Include proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.

E. Provide products produced by the manufacturers which are listed in Section 23 05 12, "Approved Manufacturers List"

F. Insulation Materials: Insulating materials manufacturing facilities must be certified and registered with an approved registrar for conformance with ISO9000 quality standard.

1.06 SUBMITTALS

A. Refer to Section 01 31 46 - "Special Requirements for Mechanical and Electrical Work", and submit shop drawings and samples.

1.07 GUARANTEE

A. Refer to Section 01 31 46 - "Special Requirements for Mechanical and Electrical Work".

1.08 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Protect insulation against dirt, water, chemical and mechanical damage. Do not install damaged insulation; remove from project site.

B. Deliver insulation, coverings, cements, adhesives and coatings to the site in factory-fabricated containers with the manufacturer's stamp, or label, affixed showing fire hazard ratings of the products.

C. Store insulation in original wrappings and protect from weather and construction traffic.

PART 2 - PRODUCTS

2.01 COLD AND DUAL TEMPERATURE PIPING INSULATION

A. The following piping shall be covered with fiberglass insulation with vapor barrier:

<table>
<thead>
<tr>
<th>Service</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Supply &amp; Return</td>
<td></td>
</tr>
<tr>
<td>Up to 1¼ &quot;</td>
<td>1½&quot;</td>
</tr>
<tr>
<td>1½&quot; and above</td>
<td>2&quot;</td>
</tr>
</tbody>
</table>
Refrigerant Suction  
   All pipe diameters  1½"

Cold Water Make-Up and Air Conditioning  
   Condensate Drain Piping from Cooling Coil Drain Pans  
   All sizes  1"

B. Insulation on any piping, fitting, flange and valve located in areas exposed to freezing (in unheated areas and where noted on the Drawings as to provide "Frost Insulation") shall be increased by one inch with the same finish as specified for the particular service when not subject to freezing. Insulation shall always be a minimum of 2½" inches in thickness.

C. Insulation shall be glass fiber complying with ASTM C547, Type I with a maximum K factor of 0.23 BTU in/hr ft² F at 75 degrees F, mean temperature with factory-applied all service vapor barrier jacket with self seal lap meeting the requirement of ASTM C-1136 Type I.

D. Insulation shall be heavy density fiberglass sectional pipe insulation as made by Owens-Corning Fiberglass Corp. or Johns-Manville Micro-Lok fiberglass insulation.

E. Ends of pipe insulation shall be sealed off at all flanges, fittings, valves and at intervals of 21 feet on continuous runs of pipe, with Foster fire-resistant vapor barrier coating Foster 30-65 or Childers CP-34 or equal.

F. All fittings, valves and flanges for pipe sizes smaller than 4" shall be insulated with molded fiberglass fittings of same thickness as the adjoining pipe insulation, secured with No. 20 gauge galvanized annealed steel wire and covered with Zeston 2000 25/50 PVC as made by Johns Manville, applied per manufacturer’s recommendation.

G. All fittings, valves and flanges for pipe sizes 4" and larger shall be insulated with fabricated mitered segments of pipe insulation of same thickness as the adjoining pipe insulation, secured with No. 20 gauge galvanized annealed steel wire and covered with Zeston 2000 25/50 PVC fitting covers as made by Johns Manville installed per manufacturer’s recommendation.

H. Finish for Exposed Pipe Insulation:
   1. The term “exposed” is hereby defined as any place outdoors, as well as any place indoors in Mechanical Rooms, Storage Rooms, Janitor’s Closets, etc., where located within 7 feet of floor or access platforms.
   2. All exposed outdoor pipe, valve and fittings insulation shall have 0.016 inch thick corrugated aluminum jacket banded with ½" s.s. bands spaced 12 inches o.c. Piping, fittings and valves exposed in building, within seven feet of the floor or access platform, shall have 0.016" thick aluminum jacket banded with ½" aluminum bands spaced 18" o.c. or two bands per section. Joints and jacket shall provide complete weatherproof protection either by mechanical contact or by use of Foster 95-44 or Childers CP-76 metal jacketing sealant (gallon cans only; no tubes).

I. All below ambient, coated molded fittings and mitered segments shall be vapor sealed with a layer of open weave glass fabric embedded between two 1/16" thick coats of Foster 30-65 or Childers CP-34 vapor barrier coating and lap seal at least 1" for molded type and 2" for mitered type on itself and adjoining insulation.
J. Direct contact between pipe and hanger shall be avoided. Hanger shall pass outside of a metal saddle which shall support a section of high density insulation equal thickness to adjacent insulation (such as calcium silicate) and of sufficient length to support pipe without crushing insulation. (See table below.) Hangers shall not pierce insulation and all vapor barriers shall be unbroken and continuous.

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Saddle &amp; Insert Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1½&quot;- 2&quot;</td>
<td>10&quot; Long</td>
</tr>
<tr>
<td>3&quot;-6&quot;</td>
<td>12&quot; Long</td>
</tr>
<tr>
<td>8&quot;-10&quot;</td>
<td>16&quot; Long</td>
</tr>
<tr>
<td>12&quot; &amp; Over</td>
<td>22&quot; Long</td>
</tr>
</tbody>
</table>

K. At pipe supports, insulation shield protection saddles and matching hanger shall be used.

L. As an alternative to fiberglass insulation, on cold pipes, elastomeric closed-cell insulation may be used.
   1. Insulation material shall be a flexible, closed-cell elastomeric insulation in tubular or sheet form: AP Armaflex, AP Armaflex W, AP Armaflex SS, or AP Armaflex SA. These products meet the requirements as defined in ASTM C 534, “Specification for preformed elastomeric cellular thermal insulation in sheet and tubular form.”
   2. Insulation materials shall have a closed-cell structure to prevent moisture from wicking which makes it an efficient insulation.
   3. Insulation material shall be manufactured without the use of CFC’s, HFC’s or HCFC’s. It is also formaldehyde free, low VOC’s, fiber free, dust free and resists mold and mildew.
   4. The insulation material shall contain MICOBAN Antimicrobial additive to aid in the prevention of mold and mildew.
   5. Materials shall have a flame spread index of less than 25 and a smoke-developed index of less than 50 when tested in accordance with ASTM E 84, latest revision. In addition, the product, when tested, shall not melt or drip flaming particles, the flame shall not be progressive and all materials shall pass simulated end-use fire tests.
   6. Materials shall have a maximum thermal conductivity of 0.25 Btu-in./h-ft- °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.
   7. Materials shall have a maximum water vapor transmission of 0.05 perm-inches when tested in accordance with ASTM E 96, Procedure A, latest revision.
   8. The material shall be manufactured under an independent third party supervision testing program covering the properties of fire performance, thermal conductivity and water vapor transmission.
   9. Valves, Flanges and Fittings:
      a. Armacell Fabricated Fittings can be used on all fittings. 2 and 3 Pieces 90s, 45s, Ts, P traps and couplings along with grooved fittings are available.
      b. All fittings shall be insulated with the same insulation thickness as the adjacent piping. All seam and mitered joints shall be adhered with Armaflex 520, 520 BLV or 520 Black Adhesive. Screwed fittings shall be sleeved and adhered with a minimum 1" overlap onto the adjacent insulation. Armaflex HT 625 Adhesive shall be used with UT Solaflex.
      c. Valves, flanges, strainers, and Grooved couplings shall be insulated using Armaflex donuts that shall then be covered with sheet or oversized tubular insulation.
10. Adhesives and Finishes
   a. Adhesive shall be the insulation manufacturer's recommended contact adhesive:
      Armaflex 520, Armaflex 520 BLV, Armaflex 520 Black, Low VOC Spray Adhesive
      or Armaflex HT 625 Adhesive.
   b. Insulation finish shall be the insulation manufacturer's recommended finish:
      Armaflex WB Finish.
   c. Accessories such as adhesives, mastic and cements shall have the same properties
      as listed above and shall not detract from any of the system ratings as specified
      above.

2.02 HOT PIPE INSULATION

A. The following piping shall be covered with fiberglass insulation:

<table>
<thead>
<tr>
<th>Service</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water Supply and Return</td>
<td></td>
</tr>
<tr>
<td>(200 Degrees F. and below)</td>
<td></td>
</tr>
<tr>
<td>*Up to 1¼&quot;</td>
<td>1½&quot;</td>
</tr>
<tr>
<td>*1½ and above</td>
<td>2&quot;</td>
</tr>
<tr>
<td>Hot Gas Refrigeration Piping</td>
<td></td>
</tr>
<tr>
<td>Exposed in Occupied Areas</td>
<td>1½&quot;</td>
</tr>
</tbody>
</table>

* Provide on piping below slab, as specified herein

B. Insulation on any piping, fitting, flange and valve located in areas exposed to freezing (in
   unheated areas, at cooling towers and where noted on the Drawings as to provide "Frost
   Insulation") shall, in addition to above covering, be increased by one inch with the same finish as
   specified for the particular service when not subject to freezing. Insulation shall always be a
   minimum of 2½" inches in thickness.

C. Insulation shall be glass fiber complying with ASTM C547, Type I with a maximum K factor of
   0.23 at 75 degrees F. mean temperature. Insulation shall be suitable for 650 degree F. (2"
   minimum thickness above 450 degrees F.).

D. Insulation shall be sectional pipe insulation as made by Owens-Corning Fiberglass Corp., or
   Johns Manville Micro-Lok fiberglass pipe insulation, with all purpose white kraft reinforced
   jacket with self-seal lap to comply with ASTM C1136 Type I.

E. Longitudinal jacket laps and butt strips shall be smoothly secured per manufacturers
   recommendations.

F. All fittings, valves and flanges for pipe sizes smaller than 4" shall be insulated with molded
   fiberglass fittings of same thickness as the adjoining pipe insulation, secured with No. 20 gauge
   galvanized annealed steel wire and covered with Zeston 2000 25/50 PVC fittings as made by
   Johns Manville.
G. All fittings, valves and flanges for pipe sizes 4" and larger shall be insulated with fabricated mitered segments of pipe insulation of same thickness as the adjoining pipe insulation, secured with No. 20 gauge galvanized annealed steel wire and covered with Zeston 2000 25/50 PVC fittings by Johns Manville.

H. Insulation shall be protected by saddles from hangers, guides and rollers.

I. Strainers on hot pipes shall not be insulated.

J. Direct contact between pipe and hanger shall be avoided. Hanger shall pass outside of a metal saddle which shall cover a section of high density insulation (such as calcium silicate) of sufficient length to support pipe without crushing insulation. (See table below.) Hangers shall not pierce insulation and all vapor barriers shall be unbroken and continuous.

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Saddle &amp; Insert Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1½&quot;- 2&quot;</td>
<td>10&quot; Long</td>
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<td>12&quot; Long</td>
</tr>
<tr>
<td>8&quot;-10&quot;</td>
<td>16&quot; Long</td>
</tr>
<tr>
<td>12&quot; &amp; Over</td>
<td>22&quot; Long</td>
</tr>
</tbody>
</table>

K. At pipe supports, insulation shield protection saddles and matching hanger shall be used.

2.03 PVC INSULATED FITTING COVERS

A. The Contractor shall use Zeston 2000 25/50 rated PVC covers as made by Johns Manville or approved equal.

B. Hot Systems: Fittings shall be insulated by applying the proper factory precut Hi-Lo Temp insulation insert to the pipe fitting. The ends of the Ho-Lo Temp insulation insert shall be tucked snugly into the throat of the fitting and the edges adjacent to the pipe covering tufted and tucked in, fully insulating the pipe fitting. PVC fitting cover is then applied and shall be secured by tack fastening, banding or taping the ends to the adjacent pipe covering.

C. On fittings where the operating temperature exceeds 250°, 2 or more layers of the Hi-Lo Temp insulation inserts shall be applied prior to the installation of the PVC fitting cover. The first layer shall be applied with a few wrappings of fiber glass yarn to eliminate voids or hot spots.

D. Cold Systems: Fittings shall be insulated by applying the proper factory precut Hi-Lo Temp insulation insert to the pipe fitting. The ends of the Hi-Lo Temp insulation insert shall be tucked snugly into the throat of the fitting and the edges adjacent to the pipe covering tufted and tucked in, fully insulating the pipe fitting. All fittings and elbows shall be coated with vapor barrier coating and reinforcing mesh before PVC covers are applied.

E. A vapor barrier mastic compatible with the PVC shall be applied around the edges of the adjoining pipe insulation and on the fitting cover throat overlap seam. The PVC fitting cover is then applied and shall be secured with pressure sensitive pearl gray Z-Tape along the circumferential edges. The tape shall extend over the adjacent pipe insulation and have an overlap on itself at least 2" on the downward side.
F. 2 or more layers of the Hi-Lo Temp insulation inserts shall be applied with the first layer being secured with a few wrappings of fiberglass yarn.

G. Refrigerant systems and cold systems located outdoors: Fittings shall be insulated to a full thickness the same as the adjacent pipe insulation, with insulation which has been mitered. An intermediate vapor barrier shall be applied, completely sealing the insulation and on the fitting cover overlap seam. 0.016" aluminum cladding shall be applied and shall be secured with pressure sensitive pearl gray Z-Tape along the throat seam and the circumferential edges overlapping itself 2" on the downward side with aluminum bands on 12" intervals.

H. Qualifications for Using Insulation: When the pipe insulation thickness is greater than 1½" or the pipe temperature is greater than 250°F or less than 45°F, additional insulation inserts should be used. Use one Hi-Lo Temp insert for each additional 1" of pipe insulation.

I. Fitting cover: The temperature of the PVC fitting cover must be kept below 150°F by the use of proper thickness of insulation and by keeping the PVC cover away from contact with, or exposure to, sources of direct or radiant heat.

J. Where insulated piping is exposed (up to 7 feet above the floor or platform) or any place outdoors, the PVC covers shall be omitted since the use of 0.016” thick aluminum cladding is required on all piping, fittings and valves.

2.04 INSULATION OF PIPING IN FAN COIL UNITS

A. The Contractor shall have the option to use ¾" thick AP Armaflex pipe insulation in lieu of fiberglass hereinbefore specified for chilled and hot water piping insulation in fan coil units. Refer to paragraph 2.01 L.

2.05 INSULATION OF HEATING HOT WATER PIPING BELOW SLAB

A. Installation shall be continuous elastomeric closed-cell foam type.

2.06 PIPING EXPOSED TO FREEZING

A. Insulation on any piping, fitting, flange and valve located in areas exposed to freezing (in unheated areas, at cooling towers and where noted on the Drawings as to provide "Frost Insulation") shall, in addition to above covering, be increased by one inch with the same finish as specified for the particular service when not subject to freezing. Insulation shall always be a minimum of 2½” inches in thickness.

B. Weatherproofing of Piping:
   1. Weatherproof all insulated outdoor piping.
   2. Where weatherproofing is required, in addition to insulation and finishes specified for frostproofing, cover with Tedlar Film Jackets as made by ALPHA Assoc, Inc. (Woodbridge N.J.).
   3. Fittings insulation shall be heavily coat with Childers CP-10/11 or Foster 46-50 weather barrier mastic for hot piping; Childers CP-34 or Foster 30-65 vapor barrier coating for cold piping. Embed into the wet coat a layer of open weave glass cloth and finish with a second coat of same mastic over entire surface.
4. In addition to insulation and finishes specified for frostproof, cover all piping, including fittings and valves, with corrugated aluminum sheet cladding, 0.016 inch thick with lock seams at longitudinal seams, and preformed straps at transverse joints at 12” intervals. Joints and jacket shall provide complete weatherproof protection either by mechanical contact or by use of Foster 95-44 or Childers CP-76 metal jacketing sealant (gallon cans only; no tubes).

2.07 FIRE STOPPING

A. Packing of openings, where ducts and pipes penetrate fire barriers, shall be done with Rockwool insulation as made by United States Gypsum, Co.

B. Insulation shall comply with Fed. Spec. HH-1-558, Form A, Class 4, K=0.24, melting point 2000 degrees F.

C. An acceptable alternative to rockwool insulation shall be 3M Product Caulk CP25 or approved equal.

2.08 DUCTWORK INSULATION

A. Insulation for Concealed Duct

1. Except where otherwise noted, all concealed rectangular and round ductwork shall be covered with flexible duct insulation with or without vapor barrier complying with ASTM C553, Types I and II and of the thickness and densities indicated below.

<table>
<thead>
<tr>
<th>Service</th>
<th>R Value</th>
<th>With</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold and Hot Air Supply Ducts</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>Return Air Ducts (only where required)</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>Hot Supply Ducts</td>
<td>6</td>
<td>---</td>
</tr>
<tr>
<td>Flexible connections to Mixing Boxes, Induction Units, Lighting Troffers</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>Outside Air Duct</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>Sound traps</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
</tbody>
</table>

B. Flexible duct insulation with vapor barrier shall be 1 lb. per cu. ft. density glass fiber with a maximum K factor of 0.29 at 75 deg. F. mean temperature, with reinforced foil-faced, flame resistant kraft vapor barrier (facing to comply with ASTM C1136, Type II).

C. Insulation with vapor barrier shall be duct wrap insulation FRK-25, type 100 as made by Owens-Corning or Johns Manville Microlite Type 100 with FSK vapor barrier facing or standard 1 lb./cf duct insulation as made by CGG with FSK facing.

D. Flexible duct insulation without vapor barrier shall be 1 lb. per cu. ft. density glass fiber with a maximum K factor of 0.29 at 75 deg. F. mean temperature and shall be Owens Corning Fiberglass Type 75P, Johns Manville Microlite Type 100 or approved equal.
E. Adhere insulation to duct with Foster fire resistant adhesive 85-60 or Childers CP-127 or approved equal, applied in 4 inch wide transverse strips at 8 inch intervals. Insulation shall be butted with facing overlapping all joints at least 2 inches and sealed with Foster fire resistant adhesive 85-60 or Childers CP-127 or equal. For insulation with vapor barrier use Foster fire resistant vapor barrier adhesive or approved equal and joints without tabs shall be firmly sealed with aluminum foil tape adhered with same adhesive. Secure insulation with 18 gauge corrosion resistant wire spaced not more than 18 inches on center. Coat all duct taped seams, punctures and breaks with Foster 30-65 or Childers CP-34 vapor barrier coating.

F. Additionally, secure insulation to bottom of rectangular ducts over 24" wide with welded pins or stick clips on 18" centers. Cut off excess pins and seal as above.

G. Insulation for Exposed Rectangular Duct

1. Except where otherwise noted, all exposed rectangular ductwork and plenums shall be covered with rigid duct insulation complying with ASTM C612 Types IA and IB and of the thickness and densities indicated below.

<table>
<thead>
<tr>
<th>Service</th>
<th>R Value</th>
<th>With</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold and Hot Air Supply Ducts in Mechanical</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>Equipment Rooms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return Air Ducts in Mechanical Equipment Room</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>Cold and Hot Air Supply Ducts Except where</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>otherwise noted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold and Hot Air Return Air Ducts Except where</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>otherwise noted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold and Hot Air Return Air Ducts Except where</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>otherwise noted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside Air Intake Ducts &amp; plenums</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>Sound Traps</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>Combustion Air Ducts &amp; plenums</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>Within 5'-0&quot; downstream and upstream of</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>Humidifier in Ducts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside and Return Mixed Air Duct</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>Hot Supply Duct</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>Exhaust Air Plenum or Duct Behind Louver up to</td>
<td>6</td>
<td>Vapor Barrier</td>
</tr>
<tr>
<td>Automatic damper</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

INSULATION FOR HVAC WORK 23 07 00-9
Exhaust Ducts connected to penthouse louvers or goosenecks up to damper

Unused portion of Louvers

Supply and Return ducts located outdoors

2. Rigid duct insulation with vapor barrier shall be 6 lbs. per cu. ft. density glass fiber with maximum K factor of 0.22 at 75 deg. F mean temperature with fire retardant vapor barrier facing all service jacket complying with ASTM C1136 Type I (white finish).

3. Rigid duct insulation with vapor barrier shall be Fiberglass Type 705 by Owens-Corning or Johns Manville, No. 817 spin-glass w/ASJ or approved equal.

4. Rigid duct insulation without vapor barrier shall be 6 lbs. per. cu. ft. density glass fiber with maximum K factor of 0.22 at 75 deg. F mean temperature with fire retardant facing foil reinforced draft. (all service jacket).

5. Rigid duct insulation without vapor barrier shall be Fiberglass type 705 by Owens-Corning, Johns Manville, No. 817 spin glass w/ASJ or approved equal.

6. Insulation shall be fastened to duct with 12 gauge welded pins and washers, or equivalent as approved. Fasteners shall be spaced 12 to 18 inches on center, a minimum of two rows per side of duct. Secure insulation in place with washers firmly embedded in insulation, or push a self-locking cap over pin after coating with fitting mastic type C by Owens-Corning or approved equal.

7. Seal all joints, breaks and impressions with Foster fire resistant vapor barrier coating Foster 30-65 or Childers CP-34, or equal, and apply 5" wide joint sealing tape to all joints. All surface must be clean and dry before applying tape.

H. As an alternative to fiberglass insulation on ducts, elastomeric closed-cell insulation may be used.

1. Insulation material shall be a flexible, closed-cell or conformable elastomeric insulation in sheet form: AP Armaflex, and AP Armaflex SA. These products meet the requirements as defined in ASTM C 534, “Specification for preformed elastomeric cellular thermal insulation in sheet and tubular form.”

2. Insulation material shall be manufactured without the use of CFC’s, HFC’s or HCFC’s. It is also formaldehyde free, low VOC’s, fiber free, dust free and resists mold and mildew.

3. The insulation material shall contain MICOBAN Antimicrobial additive to aid in the prevention of mold and mildew.

4. Materials shall have a flame spread index of less than 25 and a smoke-developed index of less than 50 when tested in accordance with ASTM E 84, latest revision. In addition, the product, when tested, shall not melt or drip flaming particles, the flame shall not be progressive and all materials shall pass simulated end-use fire tests.

5. Materials shall have a maximum thermal conductivity of 0.25 Btu-in./h-ft2- °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.
6. Materials shall have a maximum water vapor transmission of 0.05 perm-inches when tested in accordance with ASTM E 96, Procedure A, latest revision. (other than conformable elastomeric)

7. The material shall be manufactured under an independent third party supervision testing program covering the properties of fire performance, thermal conductivity and water vapor transmission.

8. Adhesives and Finishes
   a. Adhesive shall be the insulation manufacturer's recommended contact adhesive: Armaflex 520, Armaflex 520 BLV, Armaflex 520 Black, Low VOC Spray Adhesive or Armaflex HT 625 Adhesive.
   b. Insulation finish shall be the insulation manufacturer's recommended finish: Armaflex WB Finish.
   c. Accessories such as adhesives, mastics and cements shall have the same properties as listed above and shall not detract from any of the system ratings as specified above.

I. Insulation for Exposed Round Duct
   1. Insulation for exposed round ductwork shall be of material as specified for concealed ductwork and shall be covered with glass cloth or all service jacket smoothly adhered with Foster 85-60/85-20 or Childers CP-82 (5 gallons cans only) adhesive. Seal joints with 5" wide tape.

<table>
<thead>
<tr>
<th>Service</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold and Hot Air Supply Ducts in Mechanical Equipment Rooms</td>
<td>6 with vapor barrier</td>
</tr>
<tr>
<td>Air Conditioning Return Air Ducts in Mechanical Equipment Rooms</td>
<td>6 with vapor barrier</td>
</tr>
<tr>
<td>Cold and Hot Air Supply Ducts Except where otherwise noted</td>
<td>6 with vapor barrier</td>
</tr>
<tr>
<td>Hot Supply Duct</td>
<td>6</td>
</tr>
<tr>
<td>Flexible Duct Connection to Mixing Boxes, Induction Units, Lighting Troffers</td>
<td>6 with vapor barrier</td>
</tr>
<tr>
<td>Return Air Fan for Air Conditioning Units</td>
<td>6 with vapor barrier</td>
</tr>
</tbody>
</table>

2. The Contractor shall have the option to use the following material: Insulation for round ducts shall be of thickness noted above and shall be fiberglass pipe and tank insulation having a factory applied ASJ vapor barrier jacket secured with stables and ASJ pressure sensitive tape. Pipe and tank insulation is a 3.00 p.c.f. board cut into strips, fibers oriented perpendicularly to the facing it is adhered to and it must have a UL label.

3. Transition ductwork at sound traps shall be insulated with fibrous glass board with reinforced aluminum vapor barrier, Owens-Corning #705, Johns Manville 817 spin glass,
or approved equal. Fasten insulation in place with welded pins and washers or equivalent mechanical fastening method, as approved. Seal all joints with vapor barrier coating to provide continuous vapor barrier. All edges, corners and joints, reinforced with 4” wide tape. Tape, of type, and applied in strict conformance with manufacturer's recommendations. Over the insulation apply a flood coat of Foster 30-65 or Childers CP-34 or equal vapor barrier coating. Provide fiberglass fitting tape or glass cloth smoothly adhered with Foster 85-60/85-20 or Childers CP-82 (5 gallon cans only) adhesive.

PART 3 - EXECUTION

3.01 INSPECTION

A. Contractor shall examine location where this insulation is to be installed and determine space conditions and notify Architect in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install insulation in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that insulation complies with requirements and serves intended purposes.

B. Coordinate with other work as necessary to interface installation of insulation with other components of systems.

C. All insulating materials shall be applied only by experienced workmen, in accordance with the best covering practice. All piping, duct or equipment shall be blown out, cleaned, tested and painted prior to the application of any covering. Adhesives, sealers and mastics shall not be applied, when the ambient temperature is below 40°F, or surfaces that are wet.

D. Insulation for factory-fabricated air handling units, furnished as part of units.

E. At all openings in insulation and acoustical duct lining, insulate edges neatly and protect with sheet metal nosing. Use sealant as well.

F. All items described in general indicate the type of covering required, however, all piping, ductwork or equipment that transmits heat or will form condensation shall be insulated.

G. Finish for Concealed Pipe Insulation:
   1. Factory ASJ (All service jacket) secured in place with Bostich staples 4" o.c. or ASJ with self sealing lap as made by Johns Manville, Owens-Corning or approved equal. All fittings shall be covered with Zeston PVC covers.

H. All piping and ductwork insulation shall be continuous through non-fire rated ceiling openings and sleeves passing through non-fire rated walls or floors. Sleeves shall be packed with mineral wool or thermofiber. Discontinue insulation as it passes through fire-rated wall or floor and use
mineral wool or thermofiber packing instead. Specific mastics, adhesives and coating shall be applied in strict accordance with Manufacturer's instruction, including recommended coverages.

I. Where packaged type units are called for in the Specifications, or as scheduled on the Drawings, the insulation shall be as herein specified for the specific system.

J. All valved and capped outlets left for future work shall be insulated as herein specified for the specific systems with a removable section of insulation over caps.

K. Where insulation on existing piping, equipment, etc., has been cut, removed or damaged, this Contractor shall reinsulate as herein specified.

L. All insulation of access doors shall be set in sheet metal double-pan construction.

M. All ductwork shall be insulated in the field, following complete installation of the ductwork. Installation of insulation on the ductwork in the shop (prior to delivery and installation of the ductwork) is prohibited.

N. For installation of elastomeric closed-cell insulation:
   1. Piping:
      a. Install pipe insulation by slitting tubular sections and applying onto piping or tubing. Alternately, whenever possible, slide unslit sections over the open ends of piping or tubing. All seams and butt joints shall be adhered and sealed using Armaflex 520, 520 BLV or 520 Black Adhesive. When using AP Armaflex SS, only the butt joints shall be adhered using Armaflex 520, 520 BLV or 520 Black Adhesive. Armaflex HT 625 Adhesive shall be used with UT Solaflex.
      b. Insulation shall be pushed onto the pipe, never pulled. Stretching of insulation may result in open seams and joints.
      c. Tape the ends of the copper tubing before slipping the Armaflex insulation over the new pipes to prevent dust from entering the pipe.
      d. All edges shall be clean cut. Rough or jagged edges of the insulation shall not be permitted. Proper tools such as sharp non-serrated knives must be used.
      e. On cold piping, insulation shall be adhered directly to the piping at the high end of the run and every 18 feet, using a two-inch strip of Armaflex 520, 520 BLV or 520 Black Adhesive on the ID of the insulation and on the pipe. All exposed end cuts of the insulation shall be coated with Armaflex 520, 520 BLV, or 520 Black Adhesive. All penetrations through the insulation and termination points must be adhered to the substrate to prevent condensation migration.
      f. Sheet insulation shall be used on all pipes larger than 8” IPS. Insulation shall not be stretched around the pipe. On pipes larger than 12” IPS, adhere insulation directly to the pipe on the lower 1/3 of the pipe. On pipes greater than 24” IPS, complete adhesion is recommended.
      g. Seams shall be staggered when applying multiple layers of insulation.
   2. Hangers:
      a. Support piping system using high density inserts with sufficient compressive strength. The pipe support insulation shall be elastomeric foam with the same or greater thickness than the pipe insulation. All joints shall be sealed with Armaflex 520, 520 BLV or 520 Black adhesive.
b. Standard and split hangers -- Piping supported by ring hangers shall have hangers insulated with the same insulation thickness as the adjacent pipe. All seams and butt joints shall be sealed with Armaflex 520, 520 BLV or 520 Black Adhesive. Armaflex HT 625 Adhesive shall be used with UT Solaflex. Ring hangers may be sleeved using oversized tubular insulation. On cold piping, insulation shall extend up the hanger rod a distance equal to four times the insulation thickness. Insulation tape may be used to a thickness equal to the adjacent insulation thickness.

c. Clevis hangers or other pipe support systems -- Saddles shall be installed under all insulated lines at unistrut clamps, clevis hangers, or locations where the insulation may be compressed due to the weight of the pipe. All piping shall have wooden dowels or blocks of a thickness equal to the insulation inserted and adhered to the insulation between the pipe and the saddle. It is highly recommended for continuous insulation protection to use hanger sizes equal to the outer diameter of the pipe plus insulation thickness.

d. Armafix IPH or Armafix NPH can be used to prevent compression of insulation at standard split, clevis hangers or other pipe support systems. To minimize the movement of Armafix, it is recommended that a pair of non-skid pads be adhered to the clamps. In addition, to prevent loosening of the clamps, use of an anti-vibratory fastener, such as a nylon-locking nut, is also recommended.

3. Square and Rectangular Ductwork:
   a. The top of the ductwork must be sloped to prevent “ponding” of water. The recommendation is at least a 2° angle to the outer side.
   b. Armaflex Sheet Insulation shall be adhered directly to clean, oil-free surfaces with a full coverage of Armaflex 520, 520 Black or Low VOC Spray Adhesive. Armaflex HT 625 Adhesive shall be used with UT Solaflex. AP Armaflex SA shall be adhered directly to clean, oil-free surfaces.
   c. The duct insulation shall be constructed from the bottom up, with the top insulation sized to extend over the side insulation. This will form a watershed.
   d. Butt-edge seams shall be adhered using Armaflex 520, 520 Black, or HT 625 Adhesive by the compression fit method to allow for expansion/contraction. Leave a 1/2”-wide uncoated border at the butt-edge seams on the duct surface and the insulation surface. Overlap the insulation 1/4” at the butt-edges and compress the edges into place. Apply Armaflex 520, 520 Black or HT 625 Adhesive to the butt-edges of the insulation.
   e. Standing metal duct seams shall be insulated with the same insulation thickness as installed on the duct surface. Seams may be covered using strips of Armaflex Sheet Insulation or half sections of tubular pipe insulation with miter-cut ends. Standing seams shall be adhered using Armaflex 520, 520 Black or HT 625 Adhesive.
   f. Insulation seams shall be staggered when applying multiple layers of insulation.

4. Round Ductwork:
   a. AP Armaflex Sheet and Roll Insulation, UT Solaflex Roll Insulation, or NH Armaflex Sheet and Roll Insulation shall be used on all round ductwork. Insulation shall be wrapped not stretched around the duct. On ductwork larger than 12” in diameter, the insulation shall be adhered to the duct surface on the lower one third. On ductwork greater than 24” in diameter, the insulation shall be completely adhered to the duct surface. Longitudinal seams shall be located on the lower half of any round ductwork.
   b. Butt-edge seams shall be adhered using Armaflex 520, 520 Black or HT 625 Adhesive by the compression fit method to allow for expansion/contraction. Leave
a 1/2” wide uncoated border at the butt-edge seams on the duct surface and the insulation surface. Overlap the insulation 1/4” at the butt-edges and compress the edges into place. Apply Armaflex 520, 520 Black, or HT 625 Adhesive to the butt-edges of the insulation.

c. Insulation seams shall be staggered when applying multiple layers of insulation.

5. Exposed Outdoor Duct:
   a. All outdoor exposed ductwork shall be finished using one of the following applications: For all the application methods described below it is very important that the exterior horizontal surfaces shall be sloped to prevent ponding on the top surface of the coated insulation. If the substrate is not sloped make the necessary adjustments to provide for a slope. DO NOT compromise the Armaflex insulation thickness to achieve the necessary slope.

6. Armadex WB Finish
   a. All outdoor ductwork shall be finished with a minimum requirement of two coats of Armadex WB Finish.
      1) Rectangular ductwork
         a) The surface of the insulation must be clean and dry.
         b) Apply first coat of Armadex WB Finish at a rate of 400 square feet per gallon.
         c) Allow to dry at least four hours.
         d) Apply second coat at a rate of 400 square feet per gallon.

O. Finish for Exposed Insulation:
   1. The term “exposed” is hereby defined as any place outdoors, as well as any place indoors in Mechanical Rooms, Storage Rooms, Janitor’s Closets, etc., where located within 7 feet of floor or access platforms.
   2. All exposed outdoor pipe, valve and fittings insulation shall have 0.016 inch thick corrugated aluminum jacket banded with ½” s.s. bands spaced 12 inches o.c. Piping, fittings and valves exposed in building, within seven feet of the floor or access platform, shall have 0.016” thick aluminum jacket banded with ½” aluminum bands spaced 12” o.c. or two bands per section. Joints and jacket shall provide complete weatherproof protection either by mechanical contact or by use of Foster 95-44 or Childers CP-76 metal jacketing sealant (gallon cans only; no tubes).
   3. All calcium silicate pipe insulation, all insulated condenser water piping exposed to weather and all other insulated pipe exposed to weather shall have 0.016 inch thick aluminum jacket banded with ½” s.s. bands spaced 12” o.c. This shall include pipe, fittings and valves.
   4. As an alternative to the use of 0.016” aluminum cladding on outdoor duct insulation, if AP Armaflex insulation is used, the ArmaTuff laminated sheet and roll insulation may be used. ArmaTuff laminated Armadex sheet and roll insulations may be used for insulating exterior applications such as duct, tanks, vessels and large pipes. Refer to section 3.06 for further installation details. ArmaTuff is a laminate of white polymeric material on Armadex insulations, which offers durability and resistance to weathering, ultraviolet, acid rain and chemicals. The laminate is 0.013 inches (13 mils) thick. The seams must be installed in compression and sealed with Armaflex 520, or 520 Black contact adhesive. Cover the seams using ArmaTuff 6” Seal Tape.
3.03 PROTECTION

A. The installer of the insulation shall advise the Contractor of required protection for the insulation work during the remainder of the construction period, to avoid damage and deterioration.

END OF SECTION 23 07 00
PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
   
   A. This Section is coordinate with and complementary to the General Conditions and Supplementary General Conditions of the Work, wherever applicable to Mechanical Work.

   B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

1.02 DESCRIPTION OF WORK
   
   A. The Work includes providing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all piping as shown on the Drawings and hereinafter specified.

1.03 QUALITY ASSURANCE
   
   A. "Manufacturers"-Firms regularly engaged in manufacture of pipe whose products have been in satisfactory use in similar service for not less than ten (10) years.

   B. Provide pipe whose performance, under specified conditions, is certified by the manufacturer.

   C. Piping systems and installation of piping shall comply with ANSI/ASME B31.9, Building Service Piping (B31.1, Power Piping).

   Refrigerant piping systems shall comply with ANSI/ASME (B31.5, Refrigeration Piping).

   D. All piping and fittings shall be made in the USA and shall be labeled as such. Piping shall also be labeled with ASTM number for easy identification/verification at the site.

1.04 SUBMITTALS
   
   A. Refer to Section 01 31 46, "Special Requirements for Mechanical and Electrical Work", and submit shop drawings.

1.05 COORDINATION
   
   A. Refer to Section 01 31 46, "Special Requirements for Mechanical and Electrical Work".

   B. Furnish fabrication detail drawings for all pipe hangers and supports for piping 2½ inches nominal size and larger.

   C. Furnish hanger and support location drawings for piping 2½ inches nominal size and larger.
D. Perform calculations necessary for the design and selection of hangers, supports, anchors, guides, restraints, snubbers, and supplementary supporting steel for piping 2½ inches nominal size and larger.

E. Perform weight distribution, expansion and movement calculations for all piping.

F. Shop Drawings and Data: Contractor shall prepare the following drawings:
   1. Fabrication Detail Shop Drawings: These drawings shall show each pipe hanger or support for piping 2½ inches nominal size and larger and shall include location of hanger with reference to nearest building columns or beams, arrangements and detail of hanger, detail of concrete anchor or detail of welded or bolted attachment to structural steel, bill of materials for all components with ASTM specification numbers and direction and magnitude of movement and thrusts and weight at hanger point. Provide the load at each concrete anchor.
   2. Piping Erection Detail and Layout Drawings: Provide scaled detailed piping arrangement drawings showing all piping systems and connected components. Indicate piping in double line detail for all piping 2" and larger. Show piping with insulation thicknesses. Indicate all valves and valve handles, automatic actuators, strainers and access space, reducers, instruments, anchors/guides and supports, seismic components (if applicable) and all equipment to which piping is connected.
   3. Hanger and Support Location Shop Drawings: Contractor shall mark all pipe hanger and support locations for piping 2½ inches nominal size and larger on Piping Erection Detail and Layout drawings. Contractor shall also show all structural grids and support points on these drawings.

1.06 WARRANTY

A. Refer to Section 01 31 46, "Special Requirements for Mechanical and Electrical Work".

PART 2 - PRODUCTS

2.01 PIPE

A. All pipe shall be new, free from scale or rust, of the material and weight specified under the various services. Each length of pipe shall be properly marked at the mill for proper identification with name or symbol of manufacturer.

B. All steel piping, except where otherwise rated, shall be standard or extra strong weight, in conformance with the ASTM A-53 Grade B seamless, for piping 2" and larger, as manufactured by National Tube Division, Republic Steel Corp., or approved equal. Piping shall be ASTM A-53 Type F continuous butt weld, for piping less than 2".

C. All brass piping shall be standard or extra heavy weight 85% red brass semi-annealed seamless-drawn, in conformance with the ASTM B-43, as manufactured by Anaconda, American Brass Co., Chase Brass and Copper Co., or Revere Copper and Brass, Inc.

D. All copper tubing shall be of weight as required for service specified, with conformance with ASTM B-88 for Types "L" and "K" tubing, as manufactured by Chase, Anaconda, Revere, or
approved equal. Tubing and fittings shall be thoroughly cleaned with sand cloth and treated with an approved non-corrosive flux before solder is applied.

E. All galvanized steel piping shall be standard or extra strong weight, as specified, in conformance with the ASTM A-53 Grade B. Pipe shall be hot-dripped zinc-coated with Prime Western smelter and not wiped.

F. Generally, unless otherwise specified, joints in steel piping of sizes 2 inches and under shall be screwed, and all sized 2½ inches and over shall be welded or flanged. Brass pipe shall be screwed 2 inches and smaller and flanged 2½ inches and over. Copper tubing shall be silver-soldered or 95-5 solder as herein specified.

G. Screwed Piping
1. All connections to apparatus with screwed piping shall be made with 250 pound brass seat unions.
2. All screwed nipples shall be Schedule 80 nipples.

H. Welding Piping
1. All fittings for welded piping shall be as manufactured by Tube Turn, Grinnell, Bonney Forge or equal as approved by the Architect. The fittings shall be of the same weight and material as the piping to which they are attached.
2. For piping 2½" or 4" and larger, full size branch connection shall be made with manufactured welding tees, branch connections for less than full size, shall be made with welding tees or with Weldolet forged branch outlet fittings. Fishmouthing, shaped nipples, and stubbing not permitted.

I. Welding outlet fittings shall be Weldolets as manufactured by Bonney Forge, Inc., or approved equal 2 or 3 and smaller branches shall be made with thredolets as made by Bonney Forge or approved equal.

J. Weld ells shall have a center line radius not less than diameter of the pipes.

K. All flanges shall be welding neck flanges ANSI B16.5 ASTM 181 Grade I. All systems, except where otherwise noted - 150 lbs. Class, forged steel.

L. Instrumentation connections ¾" and smaller on all systems shall be provided by welding threaded 2000# forged steel half couplings to the pipe.

M. All pipe to be welded shall be cut off clean and beveled. All welding shot shall be removed.

N. Composition of welding electrodes shall be in accordance with manufacturer's recommendations.

O. Backing rings shall be used for all welded piping for high temperature hot water. High temperature hot water piping to be butt welded in sizes 2" and larger, socket welded in sizes 1½" and smaller. Rings shall be carbon steel with knock off spacer pins, for Schedule 40 and/or Schedule 80 pipe dimensions, as manufactured by Tube Turn, Inc. or Robven Backing Ring Co. Smaller branches on high temperature hot water shall be made by using "Weldolets" or approved equal fittings. Ells for high temperature hot water system shall be long radius. All flanges shall be welding neck flanges ASA B16.5 ASTM 181 Grade L,300 lbs. Class, forged steel.
P. Pipe welding shall comply with the provisions of the latest revision of the applicable code, whether ASME Boiler and Pressure Vessel Code, ANSI Code for Pressure Piping B31, or such state or local requirements as may supersede codes mentioned above.

Q. Before any pipe welding is performed, submit a copy of the welding procedure specifications together with proof of its qualification as outlined and required by the most recent issue of the code having jurisdiction. Submittal shall comply with ANSI/ASME B31.1/B31.9.

R. Before any operator shall perform any pipe welding, also submit the operator's qualification record in conformance with provisions of the code having jurisdiction, showing that the operator was tested and certified under the Procedure Specification as before mentioned. Submittal shall comply with ANSI/ASME B31.1/B31.9.

S. Assume responsibility for the quality of welding done and repair or replace any work not in accordance with these specifications.

T. In addition, all pipe welding procedures and procedures for qualification of pipe welding operators shall comply with the requirements of the American Welding Society.

U. Cut weld test plugs at locations selected at random by the Architect. The test plugs shall be tested by the testing agency approved for this project. Failure of the test plugs to meet the standards of the specified codes and agencies shall result in the complete removal and replacement of the joint and retesting of the operator who performed the welding. The removal and replacement of the joints shall be at no additional cost to the Owner.

V. Pipe Schedule: Pipe for the various services shall be as follows:

<table>
<thead>
<tr>
<th>Service</th>
<th>Material</th>
<th>Schedule</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Water</td>
<td>Brass</td>
<td>Standard</td>
<td></td>
</tr>
<tr>
<td>Cold Water</td>
<td>Copper</td>
<td>Type K</td>
<td></td>
</tr>
<tr>
<td>Hot Water (Heating) and Reheat</td>
<td>Steel</td>
<td>40 or standard</td>
<td></td>
</tr>
<tr>
<td>Branch runouts to radiation</td>
<td>Copper</td>
<td>Type L</td>
<td></td>
</tr>
<tr>
<td>Branch runouts to radiation</td>
<td>Steel</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Gas</td>
<td>Steel</td>
<td>40 or standard</td>
<td></td>
</tr>
<tr>
<td>Refrigerant</td>
<td>Copper Tubing</td>
<td>ACR Type</td>
<td></td>
</tr>
<tr>
<td>Vent (water discharge) above ground</td>
<td>Copper Tubing</td>
<td>¼&quot; Type &quot;L&quot; (soft)</td>
<td></td>
</tr>
<tr>
<td>Branch runouts below slab on grade</td>
<td>Copper</td>
<td>Type K Soft Temper</td>
<td>No joints below slab</td>
</tr>
</tbody>
</table>

W. The Contractor shall have the option to use Type K copper for hot water water piping up to and including 2".

2.02 MECHANICAL PIPE COUPLINGS

A. Grooved couplings with reverse angle pads shall engage and lock in place the grooved or shouldered pipe, pipe fittings and grooved end valves in a positive watertight couple. QuickVic™ couplings shall be “Installation Ready” stab-on design, for direct “stab” installation onto roll grooved pipe without prior field disassembly and no loose parts.
B. Grooved couplings shall consist of two places of ASTM A395 and A536 ductile iron with reverse angle pads. Coupling gaskets shall be a Grade “EHP” or “E” EPDM synthetic rubber, red or green color coded with a central cavity pressure responsive design, or other grades suitable for the intended service.
   1. Flexible type couplings shall be used in seismic areas and locations stress relief and vibration attenuation are required. Flexible couplings shall be Victaulic Style 177 QuickVic™ or Style 77 standard.

C. Coupling assembly shall be securely held together by two track-head, oval-neck, steel bolts. Bolts and nuts shall be heat-treated carbon steel and shall be in accordance with ASTM A-183-60 and A-449. Coupling on outdoor piping shall have galvanized bolts and nuts.

D. AGS grooved mechanical couplings 14" through 60" shall consist of two ASTM A536 ductile iron housings cast with a wide key profile and flat bolt pads for metal-to-metal contact, designed to fit into a deeper, wedge-shaped groove; wide-width synthetic rubber Grade “E” EPDM gasket of a FlushSeal® design, and plated steel bolts and nuts. Victaulic Style W07 (rigid) and Style W77 (flexible).

E. All pipe fittings used in connection with pipe couplings shall have grooved or shouldered ends and shall be cast of ductile iron conforming to ASTM A-395 Grade 65-45-15, and ASTM A-536 Grade 65-45-12, forged carbon steel conforming to ASTM A-234 Grade WPB, or fabricated carbon steel from ASTM-A-53 standard wall.

F. Grooved couplings and fittings for copper tubing shall be used on hard drawn ASTM B-88 copper tubing. Grooved couplings and fittings shall be copper tubing sized. Flaring of pipe ends to IPS dimensions will not be permitted.
   1. Grooved fittings shall be wrought copper per ASTM B75 or B152 and ANSI B16.22, or bronze sand casting per ASTM B584-87 copper alloy CDA 836 per ANSI B16.18. Fittings shall be copper tubing sized. (Flaring of pipe ends to IPS dimensions will not be permitted.
   2. Grooved couplings shall be ASTM A395 and A536 ductile iron, coated with copper colored alkyd enamel. Coupling housings shall be angle-pattern bolt pad type to provide system rigidity. Couplings shall be copper tubing sized. Coupling gaskets shall be grade “EMP” EPDM, UL classified in accordance with ANSI/NSF 61 for potable water service. Couplings shall be “Installation Ready” stab-on design, for direct “stab” installation onto roll grooved copper tube without prior field disassembly and no loose parts. Victaulic Stule 607 QuickVic™.

G. Before assembly of couplings, lubricate the gasket exterior including the lips and/or pipe ends housing interiors, to prevent pinching the gasket. Lubrication shall assist proper gasket seating and alignment while easing installation. Petroleum based lubricants must not be used on Grade "E" or Grade "M" gaskets. Lubricant shall be supplied by, or approved for use with the gasket, by the coupling manufacturer.

H. Pipe grooving shall be in accordance with the manufacturer's specifications.

I. Pipes, fittings, BFV's, check valves, plug valves and strainers shall be provided with groove or shouldered ends in accordance with coupling manufacturers latest published literature. Flanged or threaded end valves may be used with grooved adapters.
J. Couplings and fitting shall be designed for a system pressure specified elsewhere and in conformance with manufacturer's published data.

K. Entire coupling installation shall be done in accordance with manufacturer's latest published literature.

L. After completion of pipe coupling installation, Contractor shall furnish to the Owner's representative a signed certificate of compliance with the manufacturer's installation instructions.

M. Couplings shall be standard weight as a minimum requirement.

N. All grooved couplings, fittings, valves and specialties shall be the products of a single, ISO 9001 certified, manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

O. Install the Victaulic AGS piping system in accordance with the latest Victaulic installation instructions. Use Victaulic grooving tools with AGS roll sets to groove the pipe. Follow Victaulic guidelines for tool selection and operation. Coupling installation shall be complete when visual metal-to-metal contact is reached. AGS products shall not be installed with standard grooved end pipe or components. Installing AGS products in combination with standard grooved end products could result in joint separation and/or leakage.

P. A Victaulic factory-trained field representative shall provide on-site training to contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory-trained field representative shall periodically review product installation. Contractor shall remove and replace any improperly installed products.

2.03 FITTINGS

A. Fittings shall be specified under "Fitting Schedule" for various services.

B. Welding fittings shall be of the same material and schedule as the pipe to which they are welded. Welding elbows shall be long radius pattern unless clearance conditions necessitate the use of standard radius pattern. Welding fittings shall be as made by Tube-Turn.

C. Fittings shall be of material conforming to the following schedule:

- Steel Welding Fittings: ASTM A-106
- Forged Steel Fittings: ASTM A-234
- Malleable Iron Fittings: ASTM A-197
- Cast-Iron Fittings: ASTM A-126
- Brass Fittings: ASTM B-62
- Wrought Copper Fittings: ASTM B-75 & B-152
- Bronze Cast Fittings: ASTM B-584
- Solder Fittings: ASTM B-88

D. All fittings used at expansion loops or bends shall be extra heavy.

E. Cast-iron, malleable-iron and bronze fittings shall be of Crane manufacturer or approved equal.
F. Flanges shall be raised face, of the same weight as the fittings in each service category. All flanges shall be drilled to "US Standard" hex nuts and washers. Bolting shall conform to ASTM 193 Grade B-7, threads Class 7 fit. Nuts shall be semi-finished hexagonal, ANSI B18.2 ASTM A194 Grade 2H.
   1. Flange Adapters for grooved end pipe shall be ASTM A-395 and A-536 ductile iron, with synthetic rubber gasket. (Grade to suit the intended service.) Flange Adapters shall be CL 150, Victaulic Style 741.

G. Unions - Unions 2 inches and smaller shall be screwed. Unions 2½ inches and larger shall be flanged. Screwed unions on steel pipe, unless otherwise specified, shall be of malleable iron with bronze ground seats suitable for 300 pounds W.S.P. Screwed unions on copper or brass pipe shall be brass, ground joint suitable for 300 pounds W.S.P. Flanged unions shall be malleable iron for steel pipe, and brass for copper or brass pipe, gasket type suitable for 150 pounds W.S.P. If grooved mechanical pipe couplings are used, additional unions are not required. Couplings shall serve as unions. Unions shall be as manufactured by Crane or approved equal.

H. Brass pipe threads shall be cut with special brass treading dies, and the joints shall be made up with lubricant. Strap wrenches, or equivalent, shall be used in making up brass pipe. Wrenches which gouge or scar the pipe will not be used.

I. Solder for each solder-type fitting shall be of 95% tin and 5% antimony or silver solder, as specified herein. Refrigerant piping joints shall be made with silver solder.

J. Unless otherwise specified, all flanged joints shall be fitted with Manville or equal ring gaskets designed for the intended service.

K. Fitting Schedule: Fittings for the various services shall be as follows:

<table>
<thead>
<tr>
<th>Service</th>
<th>Size</th>
<th>Material</th>
<th>Weight</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overflow and Drain</td>
<td>ALL</td>
<td>Galv. M.I. Wrought Copper</td>
<td>150#</td>
<td>Screwed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>125#</td>
<td>Solder</td>
</tr>
<tr>
<td>Cold Water</td>
<td>ALL</td>
<td>Bronze Wrought Copper</td>
<td>125#</td>
<td>Brazed</td>
</tr>
<tr>
<td>Overflow and Drain</td>
<td>ALL</td>
<td>Wrought Copper</td>
<td>125#</td>
<td>Solder</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Grooved</td>
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<td>Bronze Wrought Copper</td>
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<td>Brazed</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>125#</td>
<td>Solder</td>
</tr>
<tr>
<td>Hot Water (Heating)</td>
<td>2&quot; &amp; Below</td>
<td>CI Steel</td>
<td>125#</td>
<td>Screwed</td>
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<td></td>
<td>2½&quot; &amp; Above</td>
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<td>Sch. 40</td>
<td>Welding</td>
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<tr>
<td>Refrigerant</td>
<td>ALL</td>
<td>Wrought Copper</td>
<td>300#</td>
<td>15% Silver</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Solder</td>
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<tr>
<td>Vent (Water Discharge)</td>
<td>ALL</td>
<td>Wrought Copper</td>
<td>125#</td>
<td>Solder</td>
</tr>
<tr>
<td>Gas</td>
<td>ALL</td>
<td>MI</td>
<td>150#</td>
<td>Screwed</td>
</tr>
</tbody>
</table>
2.04 PIPE HANGERS AND SUPPORTS

A. Provide necessary structural members, hangers and supports of approved design to keep piping in proper alignment and prevent transmission of injurious thrusts and vibrations. In all cases where hangers, brackets, etc., are supported from metal decking and/or concrete construction, care shall be taken not to weaken decking and/or concrete or penetrate waterproofing. All hangers and supports shall be capable of screw adjustment after piping is erected. Hangers supporting piping expanding into loops, bends and offsets shall be secured to the building structure in such a manner that horizontal adjustment perpendicular to the run of piping supported may be made to accommodate displacement due to expansion. All such hangers shall be finally adjusted, both in the vertical and horizontal direction, when the supported piping is hot, or chilled, as required. Hangers in direct contact with copper or brass pipe shall be solid copper.

B. Pipe hangers shall be the clevis and pipe roll types, except where otherwise noted.

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Type of Hanger</th>
<th>Make and Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grinnell Fig. No.</td>
</tr>
<tr>
<td>2&quot; &amp; smaller (steel)</td>
<td>Clevis Hanger</td>
<td>260</td>
</tr>
<tr>
<td>2&quot; &amp; smaller (copper)</td>
<td>Adjustable Wrought Iron</td>
<td>CT-65</td>
</tr>
<tr>
<td>2½&quot; to 4&quot; (steel)</td>
<td>Adjustable Steel Yoke Pipe Roll</td>
<td>181</td>
</tr>
<tr>
<td>2½&quot; to 4&quot; (copper)</td>
<td>Adjustable Swivel Ring</td>
<td>CT-69</td>
</tr>
<tr>
<td>5&quot; &amp; above</td>
<td>Two Rod Roller Hanger</td>
<td>171</td>
</tr>
</tbody>
</table>

C. Beam clamps - Hangers supported from floor steel shall be approved I beam clamps. I beam clamps for hangers shall be wrought steel. B-Line Fig. B3055 (C&P Fig. No 268) or equal.

D. Where piping is run near the floor and not hung from the ceiling construction but is supported from the floor, such supports shall be of pipe standards with base flange and adjustable top yoke similar to B-Line Fig. B3091 (C&P Fig. 247) or equal.

E. All vertical piping shall be anchored by means of heavy steel clamps securely bolted or welded to the piping, and with end extension bearing on the building.

F. All vertical piping shall be guided at each floor by use of clamps fastened to building structure. Provide 360° protective saddle at guides. Saddles shall be fastened to pipe or insulation.

G. Vertical runs of pipe not over 15 feet long shall be supported by hangers placed not over one foot from the elbows on the connecting horizontal runs.

H. Vertical runs of pipe over 15 feet long but not over 60 feet long and not over 6 inches in size, or not over 30 feet long and not over 12 inches in size, shall be supported on heavy steel clamps. Clamps shall be bolted tightly around the pipes and shall reset securely on the building structure.
without blocking. Clamps shall be welded to the pipes or placed below couplings. Clamps shall be B-Line Fig. B3373 or equal.

I. For all chilled water, dual temperature water, makeup water and insulated refrigerant piping, provide "Insulshield" as made by Insulcoistic Corp. or pipe covering protection shield B-Line Fig. B3151 (C&P Fig. 265P) with steel shield min. 9 inches long, with vapor barrier jacket. For steam, condensate, hot fuel oil and hot-water heating piping 2 inches and smaller, same as above. For steam, condensate and hot-water heating and high temperature hot water piping 2½ inches and larger, provide steel pipe covering protection saddles B-Line Fig. B3160 (C&P Fig. 353 series).

J. Piping in trenches shall reset or hang from angle iron cross supports provided by the Contractor with two coatings of red primer and final coat for black asphaltum paint.

K. Hanger rods shall be of the following diameters:

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Rod Diameter</th>
<th>Max. Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1¼ inch &amp; below</td>
<td>½ inch</td>
<td>6'-0&quot;</td>
</tr>
<tr>
<td>1½ and 2 inch</td>
<td>½ inch</td>
<td>10'-0&quot; (copper 8'-0&quot;)</td>
</tr>
<tr>
<td>2½ inch 3 inch</td>
<td>½ inch</td>
<td>10'-0&quot; (copper 8'-0&quot;)</td>
</tr>
<tr>
<td>4 inch 5 inch</td>
<td>¾ inch</td>
<td>12'-0&quot;</td>
</tr>
<tr>
<td>6 inch</td>
<td>¾ inch</td>
<td>12'-0&quot;</td>
</tr>
<tr>
<td>8 inch &amp; above</td>
<td>½ inch</td>
<td>12'-0&quot;</td>
</tr>
</tbody>
</table>

L. Hanger rods shall be attached to preset concrete inserts with steel reinforcing rod through the insert and both ends hooked over the reinforcing mesh. For pipes 4 inches and larger, rods shall extend through concrete slab above where they shall be attached to steel bearing plates 6" x 6" x ¼".

M. All trapeze pipe supports shall be constructed of angle iron or C-channel. Uni-strut type supports are acceptable only for medical gas piping. Insulated refrigerant piping may be supported using strut type supports as long as AP Armadillo insulation is used and the strut clamp is a Series 72 "Klo-Shure" by Hydra-Zorb which is intentionally oversized to match the O.D. of the insulation and includes a plastic clamp collar insert. All angle iron supports located outdoors (trapeze supports or vertical components) shall be of galvanized or stainless steel, including all related support rods and hardware.

N. Piping shall not be hung from other piping, ducts, conduits or from equipment of other trades and no vertical expansion shields will be permitted. Hanger rods shall not pierce ducts.

O. All water piping connected to rotating equipment within all mechanical spaces shall be isolated from the building structure by means of vibration hangers inserted in the hanger rods. The vibration hangers shall consist of a steel spring in combination with a double deflection neoprene element within a rectangular steel housing. Combined static deflection shall be 1.375" minimum. Hangers shall have capability of supporting the piping at a fixed elevation during
installation and shall incorporate an adjusting device to transfer the load to the spring. Deflection shall be indicated by means of scale. Vibration hangers shall be type PCDNHS made by Mason Industries. Provide flexible pipe connectors at all pump suction and discharge piping.

P. Where additional steel is required for the support of hangers, furnish and install same subject to the approval of the Architect. Piping and ductwork shall not be supported from concrete slab construction at ceiling.

Q. All piping running on walls shall be supported by means of hanger suspended from heavy angle iron wall brackets. No wall hooks will be permitted.

R. Lateral bracing of horizontal pipe shall be provided where required to prevent side sway or vibration. The lateral bracing shall be of a type approved by the Architect and shall be installed where directed by the Architect.

S. All heavy piping is defined as follows:
1. individual pipes having a nom. dia. greater than 12 inches.
2. groups of pipes consisting of more than three 8 inch, or more than two 10 inch nom. dia. pipes,
3. Any combination of closely spaced pipes weighing more than the equivalent of above or 15 lb. per lin. ft., shall be supported at all cross points with overhead floor beams by fastening to the flange of such beams with steel clamps or other suitable means.

T. Where such heavy piping runs parallel with the floor beams properly designed auxiliary steel must be provided. The spacing of such auxiliary steel supports shall in no case be greater than the spacing of the floor beams running perpendicular to the corrugations of the permanent slab steel forms.

U. Assume the responsibility for the proper transfer of the loads of the piping systems to the structure. No additional cost to the Owner should be expected for any corrective work during construction.

V. Rigid type grooved mechanical couplings shall be complete with reverse-angle bolt pads to meet support and hanging requirements corresponding to ANSI B31.1, B31.9, and NFPA 13.

2.05 ANCHORS

A. All anchors shall be separate and independent of all hangers, guides, and supports. Anchors shall be of heavy blacksmith construction suitable in every way for the work approved by the Architect. Anchors shall be welded to the pipe and fastened to the structure with bolts.

B. Anchors shall be fabricated and assembled in such a form as to secure the piping in a fixed position. They shall permit the line to take up its expansion and contraction freely in opposite directions away from the anchored points; and shall be so arranged as to be structurally suitable for particular location, and line loading. Submit calculations and details for approval.
PART 3 - EXECUTION

3.01 INSPECTION

A. Contractor shall examine location where the piping is to be installed and determine space conditions and notify Architect in writing of conditions detrimental to proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Coordinate with other work as necessary to interface installation of piping with other components of systems.

B. Provide and erect in a workmanlike manner, according to the best practices of the trade, all piping shown on the Drawings or required to complete the installation intended by these Specifications.

C. The Drawings indicate schematically the size and location of piping. Piping shall be set up and down and offset to meet field conditions and to provide adequate maintenance room and headroom in the Mechanical Rooms.

D. Study the General Construction Specifications and Plans, of the exact dimension of finished work and of the height of finished ceilings in all rooms where radiation, units, equipment or pipes are to be placed and arrange the work in accordance with the Schedule of Interior Finishes, as indicated on the Architectural Drawings.

E. All piping shall be run perpendicular and/or parallel to floors, interior walls, etc. Piping and valves shall be grouped neatly and shall be run so as to avoid reducing headroom or passage clearance. Provide min. 7'-6" headroom under passageway in mechanical equipment room. All valves, controls and accessories concealed in furred spaces and requiring access for operation and maintenance shall be arranged to assure the use of a minimum number of access doors.

F. All pipe lines made with screwed fittings must be provided with sufficient number of flanges or unions to enable the removal of piping without breakage of fittings.

G. All piping shall be erected as to insure a perfect and noiseless circulation throughout the system. No bull head tees will be permitted.

H. All valves and specialties shall be placed so as to permit easy operation and access.

I. Provide proper provision for expansion and contraction in all portions of pipe work, to prevent undue strains on piping or apparatus connected therewith. Provide signed and sealed pipe expansion calculations by an independent, licensed NYS Professional Engineer to substantiate all such provisions for said expansion and contraction. These calculations shall be based on the piping shop drawings. Provide double swings at riser transfers and other offsets wherever possible, to take up expansion. Arrange riser branches to take up motion of riser.
J. Approved bolted, gasketed, flanges (screwed or welded) shall be installed at all apparatus and appurtenances, and wherever else required to permit easy connection and disconnection. Screwed unions shall be used on piping 2” or less.

K. All piping connections to coils and equipment shall be made with offsets provided with screwed or welded bolted flanges arranged so that the equipment can be serviced or removed without dismantling the piping.

L. If, after plant is in operation, any coils or other apparatus are stratified or air bound (by vacuum or pressure), they shall be repiped with new approved and necessary fittings, air vents, or vacuum breakers at no extra cost. If connections are concealed in furring, floors, or ceilings, the Contractor shall bear all expenses of tearing up and refinishing construction and finish, leaving same in as good condition as before it was disturbed.

M. Fittings shall be of the eccentric reducing type, where changes of size occur in horizontal piping to provide for proper drainage or venting. Steel pipe bends shall be made of the very best grade open hearth, low carbon steel, leaving a smooth uniform exterior and interior surface. Pipe bends shall be made with seamless steel pipe, having a minimum radius of not less than five (5) pipe diameters.

N. Tubing shall be erected neatly in a workmanlike manner. Bends in soft copper tubing benders to prevent deformation of the tubing in the bends. Approved seat-to-pipe threaded adapters shall be provided for junctions with valves and other equipment having threaded connections.

O. Vertical sections of main risers shall be constructed of pipe lengths welded together. No couplings shall be used.

P. The ends of all pipe and nipples shall be thoroughly reamed to the full inside diameter of the pipe and all burrs formed in the cutting of the pipes shall be removed.

Q. Piping shall be installed in accordance with the latest edition of the ASME Code for Pressure Piping.

R. All piping shall be concealed above furred ceilings in rooms where such ceilings are provided (except where specifically indicated otherwise on the drawings, or in walls or partitions, except as otherwise indicated).

S. Piping, fittings or valves of dissimilar materials shall be connected with dielectric connectors as made by Ebco Company or approved equal.

T. Piping at all equipment and valves shall be supported to prevent strains or distortions in the connected equipment and valves. Piping shall be sufficiently supported to allow for removal of equipment, valves and accessories with a minimum of dismantling and without causing excessive stress or damage to the remaining piping, valves or equipment, without requiring additional supports after these items are removed.

U. Pipe nipples - Any piece of pipe 3” in length and less shall be considered a nipple. All nipples with unthreaded portion 1½” and less shall be extra heavy. Only shoulder nipples shall be used. No close nipples will be permitted.
V. Screw threads shall be cut clean and true; screw joints made tight without caulking. No caulking will be permitted. A non-hardening lubricant shall be used. No bushings shall be used. Reductions, otherwise causing objectionable water or air pockets, to be made with eccentric reducers or eccentric fittings.

W. Pitch water piping upward one inch per 100 feet in direction of flow to ensure adequate flow without air binding, and to prevent noise and water hammer. Pitch drain piping 1/8 inch per foot in the direction of flow. Branch connections to mains are to be made in such a manner as to prevent air trapping and permit free passage of air. To meet job conditions, mains shall set up to maintain headroom, and clear other trades. Provide oversized float operated automatic air vent (with valve). Avoid 90° lift set-ups in supply lines by using 45 degree ells. Where 90° lifts exceed 12" install automatic air vent in supply lines. All lifts in return lines shall be installed with automatic air vents. Pipe outlet of all automatic air vents to an open sight drain if the vent is concealed, or to within two feet of the floor within machine rooms. All water piping shall pitch back to low points for drainage. Low points shall be provided with capped 9/16 inch hose cocks.

X. Provide drain valves at the heel of all interior main water risers. Provide capped drain valves at the heel of all perimeter water risers.

Y. Provide isolation valves where tying new piping into the existing system. Refer to the valves specifications for the proper valve type for the service. Refer to the Drawings for the pipe/valve size. In addition to the isolation valves at the tie-in points, also provide a balancing valve on the supply side for chilled water, chilled glycol/brine, condenser water and heating/reheat hot water system tie-ins.

Z. Miscellaneous drains, vents, reliefs, and overflows from tanks, equipment, piping, relief valves, pumps, etc., shall be run to the nearest open sight drain or roof drain. Provide capped drain valves whenever required for complete drainage of piping, including the system side of all pumps.

AA. Provide domestic water connections from valved outlets to any equipment requiring same.

BB. All drain piping from condensate drain pans shall be properly trapped in accordance with the static pressures involved. Provide cleanout at first change in direction or before the trap. Condensate drain piping sizes shall be not less than 1½" except that fan coil unit drains may be 1¾".

CC. Vent piping from the high temperature hot water system shall comply with all requirements of high temperature hot water piping specified herebefore. This shall also apply for the high temperature water safety valve discharge piping.

DD. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.

EE. Contractor shall utilize a Smog-Hog (or similar) type local exhaust system vented to the outdoors, when welding steel pipe and/or soldering pipe inside the building.
3.03 FIELD QUALITY CONTROL

A. Upon completion of installation of piping (partial or complete) test piping to demonstrate compliance with requirements. Where possible, field correct malfunctioning piping, then retest to demonstrate compliance. Replace piping which cannot be satisfactorily corrected. Refer to Section 23 05 93 - Testing and Balancing.

END OF SECTION 23 20 00
SECTION 23 31 13
SHEET METAL DUCTWORK

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
   A. This Section is coordinate with and complementary to the General Conditions and Supplementary General Conditions of the work, wherever applicable to Mechanical Work.
   B. Section 01 31 46 - Special Requirements for Mechanical and Electrical work shall apply.

1.02 DESCRIPTION OF WORK
   A. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all Sheet Metal Ductwork as shown on the drawings and hereinafter specified.
   B. See drawings for FRP ductwork below grade.

1.03 QUALITY ASSURANCE
   A. Fabrication and installation shall be by a single firm specializing and experience in metal ductwork for not less than 10 years.
   B. Comply with SMACNA’s (Sheet Metal and Air Conditioning Contractors National Association) 2005 “HVAC Duct Construction Standards, Metal and Flexible”, Third Edition recommendations for fabrication, construction and details and installation procedures, except as otherwise indicated.
   C. Comply with ASHRAE (American Society of Heating Refrigeration and Air Conditioning Engineers) recommendations, except as otherwise indicated.
   D. Compliance to SMACNA and ASHRAE is a minimum requirement. In case of disagreement between sheet metal work described in this Section and SMACNA or ASHRAE, the specification shall govern.

1.04 SUBMITTALS
   A. Refer to Section 01 31 46 - Special Requirements for Mechanical and Electrical work and submit shop drawings and coordinate drawings.
   B. Before submitting any sheet metal drawings, submit a complete set of shop standards for review and approval. Sheet metal shop drawings may be submitted only after approval of the shop standards.

1.05 COORDINATION
   A. Refer to Section 01 31 46 - Special Requirements for Mechanical and Electrical work.
1.06 GUARANTEE

A. Refer to Section 01 31 46 - Special Requirements for Mechanical and Electrical work.

B. Contractor will guarantee all work for one year from the date of acceptance against all defect in material, equipment and workmanship. This guarantee shall include repair of damage to any part of the premises resulting from leaks or other defects in material, equipment or workmanship.

1.07 PRODUCT HANDLING

A. Protect shop fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Protect ends of ductwork and prevent dirt and moisture from entering ducts and fittings.

B. Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclosed with waterproof wrapping.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR DUCTWORK

A. Furnish and install the size, connections and run of ducts as indicated on the drawings.

B. While the Drawings shall be adhered to as closely as possible, the Architect's right is reserved to vary the run and size of ducts during the progress of the work if required to meet structural conditions.

C. Install all ductwork in strict adherence to the ceiling height schedule indicated on the Architect's Drawings. Consult with the Plumbing, Fire Protection and Electrical Contractors and, in conjunction with the above Contractors, establish the necessary space requirements for each trade.

D. The sheet metal ductwork shall, whether indicated or not, rise and/or drop and/or change in shape to clear any and all conduits, lighting fixtures, piping and equipment to maintain the desired ceiling heights and to provide adequate maintenance room and headroom in mechanical equipment rooms.

E. The ductwork shall be continuous, with airtight joints and seams presenting a smooth surface on the inside and neatly finished on the outside. Ducts shall be constructed with curves and bends so as to affect an easy flow of air. Unless otherwise shown on the Drawings, the inside radius of all curves and bends shall be not less than width of ducts in plane of bend.

F. All rectangular ductwork, unless otherwise noted, shall be built from galvanized sheet steel and thoroughly braced and stiffened.

1. Provide 18" x 18" access doors for every 30'-0" run of return air duct for cleaning purposes. For ducts whose height or width is less than 20", provide access doors which are 18" wide by a height calculated as 2" less than the height of the duct (thereby providing 1" of clearance between the bottom of the access door and the bottom of the duct, and similar for the top).
G. All outside air intake and boiler room combustion air ducts and plenums between intake point and air handling unit or mixed air duct or plenum, for at least 10 feet of duct length, shall be aluminum construction with all joints sealed with Foster 32-19, Childers CP-146 or 3M EC-800 sealer.

H. All air ducts exposed to the weather and not insulated shall be constructed of aluminum and shall be properly braced and supported and secured to the building construction. All seams shall be sealed with Foster 32-19, Childers CP-146 or 3M EC-800 sealer.
   1. The construction of ductwork shall be same as conventional ductwork except where transverse reinforcing angles not required, provide 1" x 1" x ½" black iron bracing angles matched angles at joint and 1" x 1" x ½" black iron between joints 4'-0" from joints.
   2. Provide ½" thick gasket (3M EC-1202 or equal) for all matched angles.
   3. Edge of ducts shall be bent ½" over matched angles to obtain watertight seal.
   4. Rivet angles to duct and seal with Foster 32-19, Childers CP-146 or 3M EC-800 sealer.
   5. Paint black iron angles after installation.

I. All exposed ductwork required to be painted by the GC shall be fabricated from phosphatized sheet metal to improve paint adhesion

2.02 DUCT PENETRATION THRU FLOOR

A. Provide 4" high and 4" wide concrete curb all around opening at duct penetration thru floors. Fill in space between duct and floor construction with mineral wool.

2.03 DRIP PANS

A. Provide aluminum drip pans and gutters under all equipment subject to leaks mounted above electrical equipment. Each drip pan shall be properly pitched and a drain outlet provided and piped to drain. See "Drip Pans" under Section 01 31 46 - Special Requirements for Mechanical and Electrical Work.

2.04 AUXILIARY AND SECONDARY DRAINS

A. A secondary/auxiliary drain pan shall be provided below air handling and fan coil units providing cooling which are suspended above a hung ceiling or hung from the slab or building structure above with no hung ceiling and which have no means of detecting high water level in the unit drain pan and shutting down the unit to prevent overflow.

B. Requirement for secondary/auxiliary drain pans shall not apply to units hung in mechanical equipment rooms.

C. The secondary/auxiliary drain pan shall comply with the following:
   1. Shall have a separate drain line from the primary drain pan in the unit
   2. The drain line shall be piped to the nearest floor drain or slop sink, if not, specifically routed and shown on the drawings
   3. Drain pan shall have a minimum depth of 1.5 inches and shall be not less than 3 inches larger than the unit or coil dimension width and length
   4. Pan shall be galvanized steel minimum thickness 0.0276 inches
2.05 MOISTURE ELIMINATORS

A. Provide moisture eliminators immediately downstream of all humidifiers cooling coils/and where shown on the drawings.

B. Construct the eliminators to provide three changes of direction for the air stream. Provide projections at each change of direction to prevent carry-over of water droplets that impinge on each blade and to facilitate draining into drain pan. Provide intermediate bracing of the same material and gage as the eliminator blade to prevent vibration and distortion of the blades.

C. Make eliminators equal to the entire bank of cooling coils and equal outside air duct size in height and width and 6"long overall in the direction of air flow. Drain eliminators into the cooling coil drain pan. Make the pan of adequate length to accommodate the drippings.

D. Construct all fasteners and supports of the same material as the eliminator blades.

E. Construct eliminators of 32 ounce copper for cooling coils.

2.06 INSTALLATION OF HVAC DEVICES

A. Installation of Duct Smoke Detectors: Duct smoke detectors shall be furnished by the Electrical Contractor and shall be installed in the ductwork under this Section. Provide an access door to each smoke detector.

B. Installation of Dampers: Refer to Drawings and temperature control specification for smoke dampers and other automatic dampers and install them in ductwork.

C. Installation of variable air volume system control devices: Install in sheet metal ductwork all control devices furnished by the manufacturer of the variable air volume system controls. Provide an access door at each location.

2.07 DUCT FABRICATION

A. Ducts shall be neatly finished on the outside with all sharp edges removed.

B. Inside surfaces shall be smooth with no projections into the air stream except where otherwise indicated.

C. Longitudinal joints shall be Pittsburgh lock at corners or Acme lock on flat surfaces double seams hammered tight and shall be located above the horizontal axis of the duct. A snap lock seam shall not be permitted as a substitute for the Pittsburgh lock at corners of ducts.

D. Transverse joints shall be made airtight with all laps in the directions of air flow.

E. All fasteners and attachments shall be made of the same material as the ducts.

F. Furnish test wells 12" on the center horizontally and vertically in the suction and discharge duct of each fan. Test wells shall consist of a 1" x ¾", 125 lb., bronze, screwed hex bushing, secured to the duct with a bronze hex locknut on the inside of the duct. A ¾" x 2" long standard weight bronze, screwed nipple and cap shall be fitted to the housing on the outside of the duct. Test wells shall be No. 699 as made by Ventlok or approved equal.
G. All turns in ductwork shall be accomplished using radius elbows rather than square elbows. Square elbows will only be permitted in instances where the Contractor, through depiction on their sheet metal shop drawings, proves that only a square elbow may be installed due to such limited space availability. All radius elbows shall have a minimum centerline radius of 1½ times the width of the duct.

H. All square elbows shall have factory-designed and built single thick turning vanes. Shop fabricated vanes will not be approved. Where turning vanes are in conflict with the access doors to fire dampers, they shall be made movable so that fire dampers shall be accessible.

I. Dissimilar metals shall be connected with flanged joints made up with fiber or neoprene gaskets to prevent contact between dissimilar metals. Flanges shall be fastened with bolts protected by ferrules and washers made of the same materials as the gaskets. Where an aluminum duct is to be connected to a galvanized steel duct, the end of the galvanized steel duct shall be coated with heavy black asphaltum paint before connecting it to the aluminum duct.

J. Changes in shape and dimension shall conform to the following: Except where otherwise noted, for increases in cross-sectional area, the shape of the transformation shall not exceed 1" in 7". Except where otherwise noted, for reductions in area, the slope shall not be less than 1" in 4" but 1" in 7" preferred.

K. Wherever it may be necessary to make provisions for vertical hangers of the ceiling construction passing through ducts, provide streamlined shaped sleeves around such ceiling construction hangers as to fully protect the duct from being penetrated with holes for the passage of such hangers. Any such streamlined sleeves shall be made air tight at top and bottom of ducts. In no case shall there be more than two rods in any 9 sq. ft. area. No rods shall pierce ducts smaller than 12" in horizontal area.

L. The construction for low pressure rectangular sheet metal ducts shall be made in accordance with recommendations of ASHRAE Guide, Latest Edition, or as per SMACNA Manual but not less than the following weights and construction:

<table>
<thead>
<tr>
<th>Dimension Longest Side Inches</th>
<th>Sheet Metal Gauge Steel Gauge</th>
<th>All Four Sides Aluminum Thickness In.</th>
<th>Copper Oz. Per Sq. Ft.</th>
<th>Transverse Reinforcing at Joints and Between Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up thru 12</td>
<td>26</td>
<td>0.020</td>
<td>16</td>
<td>1&quot; pocket lock 24 gauge, standing seam joint 24 gauge, 1&quot; standing S slip 24 gauge. Joint max. on 8 ft. centers.</td>
</tr>
<tr>
<td>13 thru 18</td>
<td>24</td>
<td>0.025</td>
<td>24</td>
<td>Same as for up thru 12.</td>
</tr>
<tr>
<td>19 thru 30</td>
<td>24</td>
<td>0.025</td>
<td>24</td>
<td>1&quot; pocket lock 22 gauge. Joints max, on 8 ft. centers with 1 x 1 x ½ in. angles 4 feet from joint.</td>
</tr>
<tr>
<td>31 thru 42</td>
<td>22</td>
<td>0.032</td>
<td>32</td>
<td>Same as for 19 thru 30.</td>
</tr>
</tbody>
</table>
### LOW PRESSURE - RECTANGULAR DUCTWORK

<table>
<thead>
<tr>
<th>Dimension Longest Side Inches</th>
<th>Sheet Metal Gauge All Four Sides</th>
<th>Transverse Reinforcing at Joints and Between Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steel Gauge</td>
<td>Aluminum Thickness In.</td>
</tr>
<tr>
<td>43 thru 54</td>
<td>22</td>
<td>0.032</td>
</tr>
<tr>
<td>55 thru 60</td>
<td>20</td>
<td>0.040</td>
</tr>
<tr>
<td>61 thru 84</td>
<td>20</td>
<td>0.040</td>
</tr>
<tr>
<td>85 thru 96</td>
<td>18</td>
<td>0.050</td>
</tr>
<tr>
<td>over 96</td>
<td>18</td>
<td>0.050</td>
</tr>
</tbody>
</table>

1. Flat areas of duct over 18 in. wide shall be stiffened by cross breaking of beading.
2. All joints to have corner closures.
3. All joints (longitudinal and transverse) shall be sealed with Foster 32-19, Childers CP-146 or 3M EC-800 mastic or equal UL181A approved mastic, to provide sealing equivalent to SMACNA Seal Class A.

M. The construction for low pressure round sheet metal ducts and fittings shall be as follows:

<table>
<thead>
<tr>
<th>Duct Diameter Inches</th>
<th>Steel-Galv Sheet Gage</th>
<th>Minimum Reinforcing Angle Size &amp; Maximum Longitudinal Spacing</th>
<th>Girth Joints (Continuously Welded or as Below)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up thru 8</td>
<td>26</td>
<td>None required</td>
<td>Crimped and beaded joint</td>
</tr>
<tr>
<td>9 thru 13</td>
<td>26</td>
<td>None required</td>
<td>Crimped and beaded joint</td>
</tr>
<tr>
<td>14 thru 22</td>
<td>24</td>
<td>None required</td>
<td>Crimped and beaded joint</td>
</tr>
<tr>
<td>23 thru 36</td>
<td>22</td>
<td>None required</td>
<td>--</td>
</tr>
<tr>
<td>37 thru 50</td>
<td>20</td>
<td>1¼ x 1¼ x ¼ @ 72 in.</td>
<td>--</td>
</tr>
<tr>
<td>51 thru 60</td>
<td>18</td>
<td>1¼ x 1¼ x ¼ @ 72 in.</td>
<td>--</td>
</tr>
<tr>
<td>61 thru 84</td>
<td>16</td>
<td>1½ x 1½ x ¾ @ 72 in.</td>
<td>--</td>
</tr>
</tbody>
</table>

NOTE: Flanged joints may be considered as girth reinforcing.
1. Ductwork up to 36 in. diameter shall be spiral lockseam construction and it shall be assembled with prefabricated fittings made up of 20 gauge galvanized iron.

2. All joints (longitudinal and transverse) shall be sealed tight with EC-800 to provide sealing equivalent to SMACNA Seal Class A. Joints shall, in addition, be fastened with self-tapping screws.

**N. Ductwork for medium pressure systems shall conform to the following:**

1. Medium pressure ductwork is defined as above 3” wc.

2. Duct construction shall consist of gauges and reinforcing framing specified in latest ASHRAE Guide for medium pressure ductwork or as per SMACNA Manual, but not less than the following weights and construction.

<table>
<thead>
<tr>
<th>Dimension of Longest Side Inches</th>
<th>Galvanized Sheet Gauge (All 4 Sides)</th>
<th>Transverse Reinforcing Between Joints and at Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up thru 12</td>
<td>24</td>
<td>Inside slip joint, double S slip, welded flange, standing seam, flanged joint, pocket lock, companion angle flanged joint with 1/4 x 1/4 x 3/8 angles. No tie rods required at joints. Joints max. on 8 ft. centers.</td>
</tr>
<tr>
<td>13 thru 18</td>
<td>24</td>
<td>Between Joints: 1 tie rod at 48 in. intervals on centerline of ductside or without tie rods with 1 x 1 x 16 gauge angle @ 48 in. At Joints: Inside slip joint, double S Slip and welded flange, each with 1 x 1 x 16 gauge angle. Standing seam, flanged joint, pocket lock, companion angle flanged joint with 1/4 x 1/4 x 3/8 angles. Joints max. on 8 ft. centers.</td>
</tr>
<tr>
<td>19 thru 24</td>
<td>22</td>
<td>Between Joints: 1 tie rod at 48 in. intervals on centerline of duct side or without tie rods with 1 x 1 x 3/8 angle @ 48 in. At Joints: Inside slip joint, double S slip and welded flange, each with 1 x 1 x 3/8 angle. Standing seam, flanged joint, pocket lock, companion angle flanged joint with 1/4 x 1/4 x 3/8 angles. Joint max. on 8 ft. centers.</td>
</tr>
<tr>
<td>25 thru 36</td>
<td>22</td>
<td>Between Joints: Without tie rods with 1 x 1 x 3/8 angle @ 32 in. or 1/4 x 1/4 x 3/8 angle @ 40 in. At Joints: Inside slip joint, double S slip, welded flange, each with 1/4 x 1/4 angles. Standing seam, flanged joint, pocket lock, companion angle flanged joint with 1/4 x 1/4 x 3/8 angles. Joint max. on 8 ft. centers.</td>
</tr>
<tr>
<td>37 thru 48</td>
<td>22</td>
<td>Between Joints: Without tie rods with 1/2 x 1/2 x 3/8 angle @ 30 in. At Joints: Inside slip joint, double S slip, welded flange, each with 1/2 x 1/2 x 3/8 angles. Reinforced standing seam, with 1/2 x 1/2 x 3/8 angles, companion angle flanged joint with 1/4 x 1/4 x 3/8 angles. Joints max. on 8 ft. centers.</td>
</tr>
<tr>
<td>49 thru 60</td>
<td>20</td>
<td>Between Joints: 1/2 x 1/2 x 3/8 angle @ 24 in. with tie rod in center or without tie rods with 2 x 2 x 3/8 angle @ 24 in.</td>
</tr>
<tr>
<td>Dimension of Longest Side Inches</td>
<td>Galvanized Sheet Gauge (All 4 Sides)</td>
<td>Transverse Reinforcing Between Joints and at Joints</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------------------------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>At Joints: Inside slip joint, double S slip, welded flange, each with 2 x 2 x \frac{1}{8} angles or 1\frac{1}{2} x 1\frac{1}{2} x \frac{1}{8} angles with tie rod in center. Reinforced standing seam with 2 x 2 x \frac{1}{8} angle, companion angle flanged joint with 1\frac{1}{2} x 1\frac{1}{2} x \frac{1}{8} angles. Joints max. on 8 ft. centers.</td>
</tr>
<tr>
<td>61 thru 72</td>
<td>20</td>
<td>Between Joints: 1\frac{1}{2} x 1\frac{1}{2} x \frac{1}{8} angle @ 24 in. with tie rod in center or without tie rods with 2\frac{1}{2} x 2\frac{1}{2} x 3-16 angle @ 24 in.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>At Joints: Inside slip joint, double S slip, welded flange, each with 2\frac{1}{2} x 2\frac{1}{2} x 3/16 angles or 1\frac{1}{2} x 1\frac{1}{2} x \frac{1}{8} with tie rod in center. Reinforced standing seam with 2\frac{1}{2} x 2\frac{1}{2} x 3/16 angles. Companion angle 2 x 2 x 3/16. Joints max. on 8 ft. centers.</td>
</tr>
<tr>
<td>73 thru 84</td>
<td>18</td>
<td>Same as for 61 thru 72.</td>
</tr>
<tr>
<td>85 thru 96</td>
<td>18</td>
<td>Between Joints: 1\frac{1}{2} x 1\frac{1}{2} x \frac{1}{8} angles @ 24 in. with tie rod in center.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>At Joints: Inside slip joint, double S slip, welded flange each with 1\frac{1}{2} x 1\frac{1}{2} x \frac{1}{8} angles with tie rod in center. Companion angle flanged joint with 2 x 2 x 3/16 angles or 1\frac{1}{4} x 1\frac{1}{4} x \frac{1}{8} angles with tie rod in center. Joints max. on 8 ft. centers.</td>
</tr>
<tr>
<td>97 and over</td>
<td>18</td>
<td>Between Joints: 2 x 2 x \frac{1}{8} angle @ 24 in with tie rods @ 48 in. along angle.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>At Joints: Inside slip joint, double S slip, welded flange, each with 2 x 2 x \frac{1}{8} with tie rods @ 48 in. along angle. Companion angle flanged joint with 1\frac{1}{2} x 1\frac{1}{2} x \frac{1}{8} angles with tie rods @ 48 in along angle. Joints max. on 4 ft. centers.</td>
</tr>
</tbody>
</table>

3. Transverse reinforcing must be applied on all four sides and tied together at each corner by riveting, bolting or welding, to prevent air leakage and shall be installed with \frac{1}{8}" thick 3M gasket EC-1202. Gaskets shall have overlapped corners and cove entire frame. Connecting angles shall be bolted to each other with stove bolts, spaced not more than 6" apart. In addition, each such angel frame shall be itself welded at the corners for rigidity. The longitudinal spacing of the transverse reinforcing between joints may necessarily be less than the spacings recommended in the table in order to conform to the selected length module.

4. In addition to the above, all medium pressure ductwork at supply fans, for a minimum of 30 ft. - 0 in. from supply fan shall have bracing, on each of four sides, as follows:

<table>
<thead>
<tr>
<th>Up to 60 inches</th>
<th>Over 60 inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>On 2 ft. - 0 in centers</td>
<td>On 2 ft. - 0 in. centers, plus a longitudinal angle on sides over 60 inches.</td>
</tr>
</tbody>
</table>
5. All bracing angles shall be 2" x 2" x \(\frac{3}{8}\)" and shall be tack welded or spot welded to the ducts.

6. All joints (longitudinal and transverse) shall be sealed with Foster 32-19, Childers CP-146 or 3M EC-800 mastic to provide sealing equivalent to SMACNA Seal Class A.

O. The construction of round medium pressure ducts shall be galvanized steel of gauges noted in the latest issue of ASHRAE Guide or as per SMACNA Manual but not less than the following weights and construction.

<table>
<thead>
<tr>
<th>Duct Diameter Inches</th>
<th>Steel - Galv. Sheet Gage</th>
<th>Girth Reinforcing Angle Size &amp; Maximum Longitudinal Spacing</th>
<th>Girth Joints Continuously Welded or as Below</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spiral Lock Seam Duct</td>
<td>Longitudinal Seam Duct</td>
<td>Welded Fittings</td>
</tr>
<tr>
<td>Up thru 8</td>
<td>26</td>
<td>24</td>
<td>22</td>
</tr>
<tr>
<td>9 thru 22</td>
<td>24</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>23 thru 36</td>
<td>22</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>37 thru 50</td>
<td>20</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>51 thru 60</td>
<td>-</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>61 thru 84</td>
<td>-</td>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

NOTE: Flanged joints may be considered as girth reinforcing.

1. Provide 3M Co.'s gasket EC-1202 gasket at flanged joints and all slip joints shall be sealed with Foster 32-19, Childers CP-146 or 3M Co.'s EC-800 duct sealant. Joints shall be maximum on 8 feet center.

2. This trade may elect the option of using standard prefabricated spiral construction conduit and prefabricated fittings as made by United Spiral Co. or approved equal. All joint shall be sealed with Foster 32-19, Childers CP-146 or 3M Co.'s EC-800 duct sealant.

3. All joints (longitudinal and transverse) shall be sealed with Foster 32-19, Childers CP-146 or 3M EC-800 mastic to provide sealing equivalent to SMACNA Seal Class A.

2.08 DAMPERS

A. At each main branch take-off and in such other locations where required to properly balance the system, provide volume dampers of the opposed blade, multi-louvered type, which shall be operated by indicating locable quadrants and set screws, for adjusting the system.

B. Volume dampers shall be constructed as follows: Damper blades shall not be wider than 12", shall be complete with heavy angle iron frames, connecting and operating links, brass trunnions, and bronze bearings. Dampers, unless otherwise noted, shall be fabricated with not less than No. 16 gauge sheet steel. Blades shall overlap and shall be provided with continuous stops on all four sides of dampers to prevent leakage. Blades shall be galvanized. Blades of dampers shall be set
into a flat steel frame with frame securely bolted to the duct. All dampers shall be fitted with a hexagonal brass spindle which shall extend through the exterior of duct and be fitted with an indicating self-locking regulator. Regulator shall be similar to Ventlok 641 or approved equal. All hardware shall be Ventlok or approved equal. For insulated ductwork provide No. 644 self-locking regulator as made by Ventlok or approved equal.

C. All automatic dampers shall be furnished as a part of the automatic temperature control system by the automatic temperature control manufacturer. Install dampers and provide safing in ductwork for automatic dampers smaller than duct size.

D. For stainless steel and aluminum ductwork, provide dampers of same material as ductwork.

E. All dampers shall be made accessible from building construction. Access doors in building structure shall be furnished or provided as hereinbefore specified.

2.09 SMOKE DAMPERS

A. Smoke dampers shall be classified and labeled in accordance with UL 555S, "Standard for Leakage Rated Dampers for Use in Smoke Control System." Smoke dampers shall be of UL 555S leakage class I, 4 cfm/ft² at 1" w.g.; 8 cfm/ft² at 4" w.g.

B. Smoke dampers installed at smoke barriers shall be installed no more than 2 ft. from the barrier and between any branch takeoff or duct inlet and outlets and the smoke barrier.

C. Smoke dampers shall be automatically return to closed position in the event of loss of electricity. All wiring required to interconnect the dampers with fire detection, fire alarm and fire alarm supervisory control systems shall be provided under the Division 16000 of the Specification. Pneumatic control system for damper actuators shall be provided under Section 23 09 00, as specified hereinafter. All combination fire/smoke dampers and smoke dampers shall be provided with 120 VAC actuators. Power wiring for all combination fire/smoke dampers and all smoke dampers shall be through the fire alarm system control relay and through a BAS relay and control module. The Electrical Contractor shall provide all such wiring; the ATC Sub-Contractor shall provide a BAS relay which must be installed for each combination fire/smoke damper and each smoke damper. If the air handling system is shut down, all associated combination fire/smoke dampers and all smoke dampers shall close. The fire alarm relay shall, if necessary, override the BAS relay. Each damper shall be individually powered and controlled.

D. Smoke dampers shall be constructed as described above for dampers.

E. Damper actuators shall be as specified in Section 23 09 00.

F. For fire/smoke dampers, provide two (2) damper end switches that are blade actuated to signal the fire alarm system when dampers are in the open and closed position. For smoke and fire/smoke dampers which can isolate a fan from its distribution ductwork or as otherwise required by the Sequence of Operation, provide an additional end switch which shall be wired to the fan starter (VFD) control wiring to prevent the fan from operating unless the damper is open.

G. Apply a bead of sealant between damper and sleeve and between dampers for multiple damper assemblies, as defined below for combination smoke and fire dampers.
2.10 FIRE DAMPERS

A. Fire dampers and sleeve installation shall be in accordance with NFPA-90A recommendations and shall bear U.L. Label in compliance with U.L. 555.

B. Clearly indicate fire damper location on shop drawings. Provide access doors in the ducts and supply access doors or panels at building construction at each damper of sufficient size and type to permit inspection and replacement of linkage. Assume responsibility to coordinate all locations of duct access doors with the other Contractors to conform with whatever architectural access openings may be necessary and supply access doors or panels in building construction. Provide shop drawings indicating location of access panels or doors for Architect's approval.

C. It is the intention of these plans and specifications to be complete. However, it is the responsibility of the Contractor, as being completely cognizant of local regulations, to determine where fire dampers are required and to advise the Architect prior to construction as to any discrepancies or questions in the plans or specifications.

D. Fire dampers shall be enclosed in sleeve of fourteen gage metal. Sleeve shall be secured at both sides of fire partitions with 1/2 x 1 1/2 x 14 ga. mounting angles secured to sleeves only: retaining angles must lap structural opening 1" minimum and cover corners of opening. Provide duct breakaway connections, see detail on drawings. Breakaway connections shall be located within 6 inches of the fire wall on both sides of the fire wall.

E. Dampers shall be steel plate, mounted to turn freely, in steel plate frame inserted in duct. Dampers shall be proportioned and weighted to close at once, if released from link with spring catches to hold closed, until manually reset. Dampers and frames to have suitable standard fusible-links, normally holding them open, but releasing upon contact with fire. Damper blades shall be mounted on corrosion resisting bearings. Damper shall close by gravity, moving with the air stream to full closed position against one-eighth (1/8) inch angle stop. Steel spring catch shall hold damper closed. Radius arm on shaft shall show position of damper. Submit details for approval.

F. Fire dampers shall be as made by Ruskin, Lau, Arlan Damper Corp. (631-589-7431) or approved equal, U.L. labeled.

G. Damper shall be fully out of the air stream (type B) U.O.I.

H. In stainless steel and aluminum ductwork, provide stainless steel construction fire dampers.

2.11 COMBINATION SMOKE AND FIRE DAMPERS

A. In lieu installing separate fire and smoke dampers in fire walls with a rating of two hours or less, a combination fire/smoke damper can be installed. Fire walls with a rating exceeding two hours must use separate fire and smoke dampers.

B. Combination fire/smoke dampers shall be model FSD36 as manufactured by Ruskin, Lau, Arlan Damper Corp. (631-589-7431) or approved equal.

C. Combination fire/smoke dampers shall be installed in sleeves in accordance with NFPA-90A, UL555 and manufacturer's installation instructions. Dampers shall be UL rated, UL555S, leakage class II, 4 cfm/ft² at 1 inch w.g.; 8 cfm/ft² at 4" w.g., and UL555 1 1/2 hour fire rated. Each damper
shall bear a UL label attesting to these qualifications, in accordance with established UL labeling procedure.

D. Damper manufacturer shall have tested and qualified with UL, a complete range of damper sizes covering all combination smoke and fire dampers required for this project.

E. Damper actuators shall be pneumatic or electric as specified in Section 23 09 00. Damper actuators shall be installed by the damper manufacturer at the time of damper fabrication; damper and actuator shall be supplied as a single entity which meets all applicable UL555S qualifications for both dampers and operators. Damper and actuator shall be qualified under UL555S and UL555 to an elevated temperature of 250°F.

F. Each combination fire/smoke damper shall be equipped with a fusible link which shall melt at 165°F causing the damper to close and lock in the closed position.

G. Dampers shall automatically return to closed position in the event of loss of control air or electric power.

H. Each combination fire/smoke damper shall have a factory installed sleeve of length and gauge required for satisfactory installation and with the damper actuator factory installed on the exterior of the sleeve and properly linked to the damper operating shaft. Contractor shall coordinate space requirements where dampers are located, providing required service clearance for actuators.

I. All wiring required to interconnect the dampers with fire detection, fire alarm and fire alarm supervisory control systems shall be provided under the Division 16000 of the Specification. Pneumatic control system for damper actuators shall be provided under Section 23 09 00, as specified hereinafter. All combination fire/smoke dampers and all smoke dampers shall be provided with 120 VAC actuators. Power wiring for all combination fire/smoke dampers and all smoke dampers shall be through the fire alarm system control relay and through a BAS relay and control module. The Electrical Contractor shall provide all such wiring; the ATC Sub-Contractor shall provide a BAS relay which must be installed for each combination fire/smoke damper and each smoke damper. If the air handling system is shut down, all associated combination fire/smoke dampers and all smoke dampers shall close. The fire alarm relay shall, if necessary, override the BAS relay. Each damper shall be individually powered and controlled.

J. For fire/smoke dampers, provide two (2) damper end switches that are blade actuated to signal the fire alarm system when dampers are in the open and closed position. For smoke and fire/smoke dampers which can isolate a fan from its distribution ductwork or as otherwise required by the Sequence of Operation, provide an additional end switch which shall be wired to the fan starter (VFD) control wiring to prevent the fan from operating unless the damper is open.

K. Clearly indicate fire damper location on shop drawings. Provide access doors in the duct and supply access doors for installation at building construction, at each damper, of sufficient type to permit inspection and replacement of damper actuators and linkage. Assume responsibility to coordinate all locations of access doors with other contractors. Provide shop drawings indicating locations of access doors, both duct and building construction, for Architect's approval.

L. It is the intention of these plans and specifications to be complete. However, it is the responsibility of the Contractor, as being completely cognizant of local regulations, to determine where
combination fire/smoke dampers are required and to advise the Architect prior to construction as to any discrepancies or questions in the plans or specifications.

M. Combination fire/smoke dampers shall be enclosed in a sleeve of fourteen gauge metal set and grouted into the fire partition. The sleeve shall be secured on both sides of the fire partition with 1½ x 1½ x 14 gauge mounting angles secured to the sleeves only. Retaining angles must lap structural opening 1 inch minimum and cover corners of the opening.

N. Multiple damper assemblies shall be installed and fastened together per manufacturers instructions. Unless the manufacturer's instructions indicate otherwise multiple damper assemblies shall be fastened together with ¼"-20 bolts, No. 10 screws or ½" long welds staggered intermittently on both sides. Fasteners shall be spaced 6" on center and a maximum of 2" from the ends of the joining sections or from the corner. A continuous ½" bead of Dow-Corning 100% silicon rubber, Dow-Corning Selastic 732 or GE RTV 108 sealant shall be applied on the mullion joint. Press the surface of the sealant in place to dispel any air.

O. A bead of sealant, as described above, shall be applied between the damper and the sleeve.

P. Fire/smoke dampers shall be provided with end switches (Ruskin SP100 or equal) for status indication.

Q. In stainless steel and aluminum ductwork, provide stainless steel construction combination fire/smoke dampers.

2.12 ACCESS DOORS IN SHEET METAL WORK

A. Wherever necessary in ductwork, casings or sheet metal partitions, provide suitable access doors and frames to permit inspections, operation and maintenance of all valves, coils, humidifiers, controls, smoke dampers, smoke detectors, fire dampers, filters, bearings, traps, or other apparatus concealed behind the sheet metal work. All such doors shall be of double construction of not less than No. 20 gauge sheet metal and shall have sponge rubber gaskets around their entire perimeter. Doors in insulated ducts of insulated casings shall have rigid insulation between the metal panels.

B. All access doors in sheet metal ducts shall be hung on heavy flat hinges and shall be secured in the closed position by means of cast zinc clinching type latches. Where space conditions preclude hinges, use four heavy window type latches. Doors into ducts shall in general not be smaller than 24" x 24" except for access door to fire dampers which will depend on size of fire damper.

C. In no case shall access to any items of equipment requiring inspection, adjustment, or servicing require the removal of nuts, bolts, screws, wing nuts, wedges, or any other screwed or loose device.

D. Each sheet metal chamber or plenum shall have access doors for access to all parts of the system (outside air intake, exhaust and return air). Doors shall be fitted with cast zinc door latches, two per door. Latches shall be operable from both sides of casing. Hinges shall be extra heavy, zinc plated hinges, minimum of two per door. The doors shall be felted or provided with rubber gaskets so as to make them airtight. The doors shall be made with inner and outer shells 2 inches apart so that they may be properly insulated and properly operated. Doors shall be a minimum size of 20" x 48".
E. Hinges shall be Ventlok No. 150 or 260 with or without screw holes or approved equal. Latch for walk-in access doors shall be No. 260 as made by Ventlok Co. or approved equal. Latch for access door in ductwork shall be Ventlok No. 100 or approved equal.

F. Where reheat coils are installed in ductwork, provide two (2) access doors; one on the upstream side of the coil and one on the downstream side of the coil, both within 2'-0" of the coil.

G. Access doors at humidifier locations shall be provided on both sides of duct.

H. Provide access doors of adequate size to allow easy access to the equipment that will require maintenance. Provide insulated or acoustically lined doors to prevent condensation where applicable.

I. Manufacturer to provide an installed neoprene gasket around perimeter of access door for airtight seal.

J. Systems 3" w.g. or less shall utilize a hinged, cam, or hinged & cam square-framed access door.

K. Systems 4" w.g. and above shall utilize a sandwich-type access door. Construct doors in accordance with Figure 7-3 of the 2005 SMACNA Manual, “HVAC Duct Construction Standards, Metal & Flexible” Third Edition.
   1. Approved Manufacturer: Ductmate Industries “Sandwich” style door or approved equal.

L. Grease exhaust duct doors shall be grease and air tight, UL 1978 listed, meet NFPA 96 standards and all mechanical codes. Grease duct access doors can be sandwich type or with a weld on frame, with/without hinge.
   1. Approved Manufacturer: Ductmate Industries “Ultimate” style door or approved equal.

M. All grease duct access doors used must be accompanied by independent testing in conjunction with each manufacturer's respective wrap system for high temperature applications.

2.13 FLEXIBLE CONNECTIONS

A. All fan and air supply unit connections, both at inlet and discharge shall be made with material as hereinafter specified, so as to prohibit the transfer of vibration from fans to ductwork connecting thereto.

B. The flexible connections shall be a minimum of 6" long including bands using extra wide fabric as specified and held in place with heavy metal bands, securely attached, to prevent any leakage at the connection points.

C. Flexible connections shall be fabricated from the following materials unless otherwise required by Local Authorities.
   1. Range Hood Exhaust - DDFDC-995 by Duro Dyne or equal (rated for 500°F).

D. Flexible connections shall not be painted.
E. Flexible air connectors shall be listed and labeled to the requirements of UL 181 for class 0 or class 1 flexible air connectors and shall be so identified.

2.14 AIR INTAKE AND DISCHARGES

A. Air intake and discharge louvers and screens in the facade of the building shall be furnished and installed under another contract.

B. Air intake and exhaust louvers where indicated on Contract Drawings shall be furnished and installed in this Contract. Such louvers shall be minimum 14 gauge aluminum with maximum blade length between mullions of 4'-0". Provide weathertight joints between louver frames and masonry openings by means of flashing and/or caulking. Provide ½" mesh heavy aluminum wire bird screens. Provide drain pipe at duct plenum connection to louvers - plenum bottom and 6" up each side, joints and seams to be sealed with Foster 32-19, Childers CP-146 or 3M EC-800, bottom pitches to drain connection, drain to be trapped. Inside of outside air intake plenums to be painted with two (2) coats of black asphaltum paint.

C. Louvers shall be drainable blade type having water penetration less than 0.005 oz. per Ft.² at 1,000 FPM free area velocity.

2.15 GRILLES, REGISTERS AND DIFFUSERS

A. Furnish and install where shown on the drawings all metal diffusers, grilles and registers of the sizes and capacities indicated.

B. Ceiling diffusers shall be selected to diffuse the air uniformly throughout the occupied space. The air shall be introduced at a temperature differential of 20 deg. F and shall be diffused at the five (5) foot level to a velocity of not greater than 50 FPM and a temperature differential of not greater than 2 deg. F. when compared with mean room temperature. The sound power level of air distribution equipment devices shall not exceed ratings as shown by Anemostat Corp. data.

C. Equipment manufacturer shall submit engineering data in a manner to facilitate convenient review of the following factors:
   1. Aspiration ability, including temperature and velocity traverses, throw and drop of each unit, noise criteria ratings for each unit, sizes, free area and quality of construction.

D. All air distribution equipment shall be as manufactured by Anemostat Corp., or approved, as scheduled on plans.

E. All ceiling diffusers shall be furnished with a device or devices equalize the air flow and control the volume.

F. Location of ceiling diffusers and registers shown on the drawings are approximate. Coordinate with the acoustic tile ceiling Sub-Contractor for exact locations of ceiling diffusers and registers. They shall be in accordance with approved ceiling layout shop drawings.

G. Return grilles shall match return registers Anemostat Corp. Type SS-3HD or approved equal.

H. Transfer "A" shall be a combination return register and return grille.
   1. Transfer "B" shall be two (2) return grilles.
I. All registers, grilles and diffusers shall be coated with baked aluminum enamel, baked flat white (W-1), or baked gloss white (W-4) as supplied by Anemostat Corp. unless otherwise indicated. All supply registers and grilles shall have a ¼" sponge rubber gasket around the grille frame.

J. All grilles, registers and diffusers shall be provided without an integral shut-off damper.

K. Exceptions to foregoing types of grilles, registers and diffusers shall be as indicated on the plans.

L. Each air supply outlet shall have the required capacity and shall be guaranteed to give the required draft with draftless diffusion. Where manufacturer's recommendations require duct sizes differing from those on the drawings, the same shall be provided at no additional cost to the Owner.

M. All grilles, registers and diffusers must be tested under ADC standards and carry and ADC seal of approval.

N. All registers and grilles located at face of partitions or plaster line of ceilings or soffits, etc. shall have plaster frames, Anemostat R C or approved equal.

O. Relocations of ceiling diffusers or registers in order to match the ceiling tile layout shall be made at no additional cost to Owner.

P. Exhaust registers serving shower and hydrotherapy areas shall be all aluminum construction.

Q. All exhaust registers in operating rooms, recovery rooms, delivery rooms, nurseries shall be stainless steel construction.

2.16 SOUND REDUCTION

A. Furnish and install all soundproofing material specified, indicated or necessary to that all systems will comply with requirement of quiet operation. In general, noise level in any part of building (except in machinery rooms), due to air conditioning or ventilating equipment,ducts, and outlets, shall not exceed 40 decibels at 1200-2400 cycles per second, except as otherwise hereinafter specified.

B. Furnish and install sound-absorptive lining in ductwork for locations and lengths as indicated and/or hereinafter specified. All soundproofing material, installation and arrangement, shall be as approved. Where ducts are acoustically lined and insulation is required per 15850 (23 07 00), external insulation may be omitted provided a minimum R value 6 is maintained for indoor ducts. Dimensions noted for lined ducts are inside clear dimensions. Duct sizes shall be increased for liner.

C. Sound Absorbent Duct Lining for Low Pressure Ductwork - Furnish and install as herein specified and/or shown on the drawings (except where otherwise noted) 2" thick, meeting ASTM C1071 Type I flexible with a NRC of .70 tested per ASTM C423 using a type "A" mounting, fibrous glass duct lining meeting the requirements of NFPA 90A with a FHC of 25/50, limited combustible and ASTM C411 at 250°F.

D. Liner shall be adhered to all interior sides of duct with minimum 90% coverage of fire-retardant adhesive similar to Foster 85-60 or Childers CP-127 and with weld pins and washers or equivalent mechanical fastening starting 3" from edges and sides, 12" on center all sides. Minimum one row
per side for duct size of 12" of less. Mechanical fasteners shall cause quilting of surface. Acrylic coated surface shall be toward air stream. Before installing liner, seal all butting edges and final edges with heavy coat of adhesive to seal off air between lining and duct unless the material has factory applied edge coating. All exposed edges of lining shall be installed with sheet metal nosing 1½" wide, two gauges heavier than duct at fan discharge and at any section preceded by an unlined section. Installation shall be suitable for duct velocities up to 3,000 fpm. Low pressure duct lining shall be provided where specified and/or where shown and noted on the drawings.

E. Sound Absorbent Duct Lining for Low Pressure Ductwork (Option for Elastomeric Closed-Cell Liner): Furnish and install as herein specified and/or shown on the drawings (except where otherwise noted), 2" thick, closed cell liner, K-Flex LS sheet with PSA as manufactured by Nomaco, K-Flex, AP Armaflex, AP Armaflex SA or approved equal, meeting ASTM C-534, ASTM D-1056-00-2C1 and ASTM C-1534-02 and shall have an anti-microbial ingredient. Lining shall meet the requirements of NFA 90A with a FHC of 25/50 and flammability UL 94-5V and ASTM E-84 foam core 25/50 at 1" and below, psa 0/10, R value 3.8 (1")

F. Liner shall be applied to clean, dry ductwork by peeling the release liner away and applying uniform pressure to the sheet. Compression joints with adhesive applied should be used on all butt edges. Seal all final edges with a heavy coat of adhesive to seal off air between lining and duct, unless the material has a factory applied edge coating. Follow manufacturer's installation instructions. All exposed edges of lining shall be installed with sheet metal nosing 1½" wide, two gauges heavier than duct.

G. Duct sizes indicated on drawings are clear inside dimensions. Increase sheet metal sizes as required to install acoustic lining.

H. Do not install lining within 5'-0" (downstream and upstream) of humidifier in ductwork. This portion of ductwork shall be externally insulated.

I. The following ductwork shall be acoustically lined whether or not shown on Drawings.
1. Ductwork downstream of (mixing box) (terminal) units a minimum distance of 10 feet.
2. All ductwork downstream of (mixing box) (terminal) units.
3. Single wall built-up casing walls and ceiling except that lining shall be 2" thick 4 lb. density, and inner liner of perforated galvanized sheet metal (7/64" dia. holes on 3/16" staggered centers) shall be used for all systems.
4. All conditioned air rectangular supply/return ductwork within mechanical equipment rooms, and not less than 20 ft. from fan towards occupied space for supply, exhaust and return fans.
5. Return air fan and toilet exhaust plenum walls and ceiling, except that the lining shall be 2 inch thick 4 lb. density, and inner liner of perforated galvanized sheet metal (7/64" dia. holes on 3/16" staggered centers) shall be used.
6. Combustion air ductwork.
7. Outside air duct to air handling units. (Note to Spec Writer: If insulated delete).
8. All supply, return and exhaust ductwork for auditorium, theater or multi-purpose room.

J. Sound Absorbent Duct Lining for Medium Pressure Ductwork.
1. Furnish and install 1" thick meeting ASTM C1071 Type II (board) with a NRC of .80 tested according to ASTM 423 using a Type “A” mounting, acoustical lining and meeting
requirements of NFPA 90A with a FHC of 25/50, limited combustible and ASTM C411 at 250°F, as herein specified and/or as shown on the drawings.

2. Liner shall be adhered to all interior sides of duct and plenums with minimum 90% coverage of fire-retardant adhesive similar to Foster 85-60 or Childers CP-127 and with weld pins and washers or equivalent mechanical fastening on not more than 16" centers on all sides, top and bottom of duct. Acrylic coating surface shall be toward air stream. Before installing liner, caulk all butting edges and final edges with heavy coat of adhesive to seal off air between lining and duct unless material has factory applied edge coating. Coat cap of fasteners with brush coat of fire retardant Foster Eclipse 40-11 insulation coating. Use metal corners and nosing to protect leading edges of liner insulation at fan discharge or after and any section preceded by an unlined section and at any section with an air velocity in excess of 4000 fpm. Apply light brush coat (150 sq. ft. per gallon) of fire retardant Foster Eclipse 40-11 insulation coating over all interior insulation surfaces. Installation shall be suitable for duct velocities up to 5,000 fpm.

3. The Contractor has the option to use elastomeric closed-cell insulation for lining medium and high pressure ducts. Refer to the low pressure duct lining section covering elastomeric closed-cell lining for requirements.

4. When indicated in the drawings, the sound absorption material in mechanical and high pressure ducts shall be faced with a galvanized perforated metal facing having the same dimensions as the unlined ductwork connecting to the lined section of the ductwork. The perforated metal shall be 26 gauge and have one of the following perforation patterns or approved equal.

<table>
<thead>
<tr>
<th>Open Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/64&quot; round holes on 3/16&quot; staggered centers</td>
</tr>
<tr>
<td>⅛&quot; round holes on 7/32&quot; staggered centers</td>
</tr>
<tr>
<td>⅛&quot; round holes on ¼&quot; staggered centers</td>
</tr>
<tr>
<td>.085&quot; round holes on 5/32&quot; staggered centers</td>
</tr>
<tr>
<td>1/16&quot; round holes on ⅛&quot; staggered centers</td>
</tr>
</tbody>
</table>

5. Duct sizes indicated on drawings are clear inside dimensions. Increase sheet metal sizes as required to install acoustic lining.

2.17 SOUND TRAPS

A. Furnish and install sound traps of the types and sizes shown on plans.

B. Outer casings of rectangular sound traps shall be made of 22 gauge steel in accordance with ASHRAE Guide recommended construction for high pressure rectangular ductwork. Seams shall be lock formed and mastic filled.

C. Interior partitions for rectangular sound traps shall be made of 24 gauge galvanized perforated steel.

D. Filler material shall be of inorganic mineral or glass fiber of a density sufficient to obtain the specified acoustic performance and packed under not less than 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin and moisture proof.
E. Combustion rating for the sound trap acoustic fill shall be not greater than the following, when tested in accordance with ASTM E84, NFPA Standard 255 or UL NO. 723:

- Flamespread Classification: 20
- Smoke Development Rating: 20
- Fuel Contributed: 15 - 30

F. Airtight construction shall be used, and sound traps shall be leakproof when subjected to a differential air pressure of 8" w.g. inside to outside of the sound trap casing.

G. Sound trap ratings shall be determined in a duct-to-reverberant room test facility which provides for air flow through the sound trap during rating. The test setup and procedure shall be such that all effects due to end reflection, directivity, flanking transmission, standing waves, and test chamber sound absorption are eliminated. Acoustic ratings shall include dynamic insertion loss and self-noise power levels both at 2,000 fpm face velocity as per schedule on the Drawings.

H. Static pressure loss of sound traps shall not exceed those listed in the schedule at the air flow indicated. Air flow measurements shall be made in accordance with applicable portions of ASME, AMCA and ADC air flow test codes.

I. The manufacturer shall supply with submittals certified test data on dynamic insertion loss, self-noise power levels, and aerodynamic performance. Test data shall be for a standard product having not less than 24" x 24" cross section. All rating tests shall be conducted in the same facility, shall utilize the same sound traps and shall be conducted sequentially. The certifying laboratory shall be open to inspection upon request from the architect. Provide flanges at both ends of sound traps 1 1/2" x 1 1/2" x 3/8" thick.

J. All sound traps lining shall meet with erosion test method described in U.L. No. 181 and shall be suitable for Hospital use, regardless of building type.

2.18 ACOUSTICAL PERFORMANCE SPECIFICATIONS - GENERAL

A. It is the intent of this Specification that noise levels due to air conditioning and/or ventilating equipment, ducts, grilles and registers, diffusers and air light fixtures, will permit attaining sound pressure levels in occupied spaces conforming to the following NC curves as explained in the ASHRAE Guide and Data Book.

<table>
<thead>
<tr>
<th>Room Type</th>
<th>NC Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offices</td>
<td>NC 30-40</td>
</tr>
<tr>
<td>Offices and Conference Rooms</td>
<td>NC 25-35</td>
</tr>
<tr>
<td>Teleconference Rooms</td>
<td>NC 25 (max)</td>
</tr>
<tr>
<td>Corridors and Public Spaces</td>
<td>NC 35-45</td>
</tr>
<tr>
<td>Auditorium</td>
<td>NC 25-35</td>
</tr>
<tr>
<td>Multi-Purpose Room</td>
<td>NC 30-35</td>
</tr>
</tbody>
</table>

B. Grilles, Registers, Diffusers

1. The maximum permissible sound power levels of air terminal devices when installed and operating per plans and specifications shall be as follows:
Maximum PWL re 10-12 Watts

<table>
<thead>
<tr>
<th>Octave Band</th>
<th>NC-30</th>
<th>NC-35</th>
<th>NC-40</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>62</td>
<td>64</td>
<td>66</td>
</tr>
<tr>
<td>2</td>
<td>52</td>
<td>56</td>
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<td>41</td>
<td>46</td>
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<tr>
<td>8</td>
<td>37</td>
<td>42</td>
<td>47</td>
</tr>
</tbody>
</table>

C. Sound Power Levels for air outlets and inlets shall be tested in accordance with ASHRAE Standard 70-1991.

2.19 ACOUSTICAL PERFORMANCE WITHIN EQUIPMENT SPACES

A. Equipment room noise levels and noise transmission to adjacent buildings shall comply with all Federal, State, and City Noise Ordinances.

B. Motor Acoustical Performance:
1. Motor drives for pumps and refrigerator machine when installed per plans and specifications shall operate with noise levels not to exceed 80 dbA.
2. Noise levels shall be determined in accordance with IEEE Standard #85 test "procedure for Air-Borne Noise Measurements on Rotating Electric Equipment".

PART 3 - EXECUTION

3.01 INSPECTION

A. Contractor shall examine location where ductwork is to be installed and determine space conditions and notify Architect in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF DUCTWORK

A. Install ductwork in accordance with recognized industry practices, to ensure that ductwork complies with requirements and serve intended purposes.

B. Coordinate with other work as necessary to interface installation or ductwork with other components of systems.

C. Duct sizes shown on the drawings at connection to fans or other equipment may vary in actual installation. Contractor shall provide transition pieces as required.
D. Ducts, casings and hangers shall be installed straight and level and shall be free of vibration and noise when fans are operating.

E. Ducts at ceilings shall be suspended from inserts in concrete slabs except where otherwise indicated. Inserts shall be Grinnell Fig. 279, 282, or 152 as required. Ducts at floor shall be supported by steel angles suitably anchored to floor construction. Each duct shall be independently supported and shall not be hung from or supported by another duct, pipe, conduit or equipment of any trade.

F. Supports shall be placed at each joint and change in direction up to a maximum spacing of 8 feet on centers. Prevent buckling of ductwork.

G. All fastenings to building structure shall be adequate to insure permanent stability of sheet metal work and shall be capable of resisting all applied forces.

H. Vertical ducts in shafts or passing through floors shall be supported by steel angles or channels, welded, riveted or bolted to ducts and fastened to building structural members at each floor level. Provide safining to close all floor openings around ductwork - pack annular space with rockwool and 18 gauge sheet metal safining. Floor openings in plenums shall have \( \frac{2}{3} \) inch diameter steel bars.

I. Rigid connections between ductwork and non-rotating equipment shall be made with flanged joints, sealed with fireproof material (Fiber or Neoprene gaskets).

J. It is the intent to obtain low pressure ductwork construction with minimum leakage. The construction noted in Specifications can produce low or high leakage rates, depending upon the workmanship, particularly with regard to the connection at the top of the ducts. Guarantee that total diffuser volume, measured by means of velometer, shall be at least 95% of actual fan supply (measured by means of a duct traverse taken with a Pitot tube and water manometer). Seal the ductwork at all joints (longitudinal & transverse and duct wall penetrations) with suitable sealers Foster 32-19, Childers CP-146 or 3M EC-800 and tape equivalent to SMACNA seal class A. Use of "HARDCAST" or any other material is subject to Architect's approval.

K. For leakage test for medium pressure ductwork refer to Section "Testing and Balancing".

3.03 DUCT HANGERS

A. Low pressure ducts up to 24" on a side or up to 20" diameter shall be suspended with 16 gauge, galvanized strap hangers, 1" wide.

B. Low pressure ducts 25" to 40" on a side or 21" to 42" diameter shall be suspended with galvanized strap hangers 1" wide by \( \frac{3}{16} \)" thick.

C. Strap hangers shall be bent 90°, extended down sides of ducts and turned under bottom of ducts a minimum of 2". Strap hangers shall be fastened at ceiling with nuts, bolts and lock washers and to sides and bottom of ducts with sheet metal screws.

D. All steel ductwork 43" and larger on a side or diameter shall be suspended with either steel angle type hangers with rod and trapeze.
E. No screws shall penetrate medium and high pressure ductwork.

F. Trapeze type hangers shall have steel rods threaded at both ends and bottom bracing angles on ducts, with nuts and lock washers. Threaded rod diameter shall be as scheduled on the drawings based on the size of the duct supported.

G. Angle type hangers shall be extensions of side bracing angles on ducts, bent 90° at ceiling and fastened with nuts, bolts and lock washers.

H. The minimum spacing intervals for all duct supports shall be as scheduled on the drawings based on the size of the duct supported.

I. Hangers for vertical ducts shall be as per SMACNA Duct Manual.

J. Stainless steel ductwork shall be supported with rod or angle type hangers, so that there will be no penetration of the stainless steel ducts.

K. Any steel used for support of aluminum ductwork or any ductwork located outdoors shall be constructed of galvanized or stainless steel.

L. All ductwork 43” and larger on a side or diameter shall be suspended with steel angle type hangers with rod and angle steel trapeze. The use of strut for support of any HVAC work (ducts, piping or equipment) is prohibited.

3.04 CLEANING AND PROTECTION

A. Clean ductwork internally, unit by unit as it is installed of dust and debris. Clean external surfaces of foreign substances, which might cause corrosion, deterioration of metal or interfere with painting.

B. At end of ducts which are not connected to equipment or air distribution devices at the time of ductwork installation, provide temporary closure of polyethylene film or other covering.

C. Cleaning of new and existing supply ductwork: After completion of ductwork installation clean ductwork as follows.
   1. Cover all supply registers and diffusers with oil cheese cloth.
   2. Use supply fan or install temporary fan to provide air to the system for four (4) hours.
   3. Remove oil cheese cloth.

END OF SECTION 23 31 13
PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. This Section is coordinate with and complementary to the General Conditions and Supplementary General Conditions of the Work, wherever applicable to Mechanical Work.

B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

1.02 DESCRIPTION OF WORK

A. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and made ready for operation by the Owner, all Duct Terminal Units as shown on the drawings and hereinafter specified.

1.03 QUALITY ASSURANCE

A. Firms regularly engaged in manufacture of this material with characteristics and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years.

B. Provide product produced by the manufacturers, which are listed in Section 23 05 12 "Approved Manufacturer's List".

C. Provide equipment whose performance, under specified conditions, is certified by the manufacturer.

1.04 SUBMITTALS

A. Refer to Section 01 31 46 - Special Requirements for Mechanical and Electrical Work and submit shop drawings.

1.05 COORDINATION

A. Refer to Section 01 31 46 - Special Requirements for Mechanical and Electrical Work.

1.06 GUARANTEE

A. Refer to Section 01 31 46 - Special Requirements for Mechanical and Electrical Work.
PART 2 - PRODUCTS

2.01 CONSTANT (C.A.V.) AND VARIABLE (V.A.V.) VOLUME AIR TERMINAL UNITS

A. Furnish and install pressure independent constant and variable air volume terminal units of size and capacities as shown on Drawings. Units shall be DESV as manufactured by Titus or approved equal.

B. Unit casings shall be 22 gauge galvanized steel and be fully lined with 1 inch, (½ inch is manufacturer standard), 1½ lb. density, neoprene coated fiberglass. The fiberglass shall comply with U.L.-181 for erosion, and NFPA 90A for fire resistivity. There shall be no cut edges of fiberglass exposed to the moving air stream.

C. Unit inlets shall be round or rectangular. Rectangular inlets shall have S and Drive connections. Attenuation section where called for in the Schedule shall be integral to the basic unit casing to minimize casing leakage and eliminate all field assembly.

D. Damper to be heavy gauge metal with Delrin self-lubricating bearings. Tight close-off. Damper leakage is less than 2% of nominal cfm at 3 inches sp. Terminals shall be certified under the ARI Standard 880 Certification Program and must carry the ARI Seal. For optimum control, the inlet duct must be of the same size as the assembly inlet.

E. Units shall be tested in accordance with ARI Standard 880. Unit sound power levels (second thru seventh octave band) and minimize pressure drop ratings shall not exceed those in the schedules.

F. Pressure independent air terminal units shall operate over an inlet velocity range of 0 to 3000 fpm. Terminals shall incorporate a multipoint center averaging sensor. Measuring ports in series are not acceptable. Sensors must provide control signal accuracy within ± 5%. Cfm delivery shall be in accordance with (maximum-minimum) settings and/or as required by thermostat to satisfy space-served conditions. Adjustable minimum and maximum cfm limits gauge tee for flow measurement and balancing.

G. All actuators, controls, and circuitry shall be factory furnished and installed. Control and CFM settings must be easily accessible. Access shall also be provided to inspect, clean, and remove the velocity sensing device.

H. Provide integral hot water coils as indicated on the drawings. Coils shall be as specified under "COILS" section of this Specification.

I. The integral hot water heating coils shall be of size rows and capacities as indicated in schedules.

J. Where integral hot water coils are provided, provide an access door upstream of the coil. Access door shall be factory installed. An access door shall also be provided immediately downstream of the reheat coil and may be installed in the supply air ductwork.
PART 3 - EXECUTION

3.01 INSPECTION
A. Contractor shall examine location where this equipment is to be installed and determine space conditions and notify architect in writing of conditions detrimental to proper and timely completion of the work.
B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION
A. Install equipment where shown, in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that equipment comply with requirements and serve intended purposes.
B. Coordinate with other work as necessary to interface installation of equipment with other components of systems.
C. Check alignment and, where necessary (and possible), realign shafts or motors and equipment within tolerances recommended by manufacturer.

3.03 FIELD QUALITY CONTROL
A. Upon completion of installation of equipment, test equipment to demonstrate compliance with requirement. When possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected. Refer to Section 23 05 93 - Testing and Balancing.

END OF SECTION 23 36 00
PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
A. This Section is coordinate with and complementary to the General Conditions and Supplementary General Conditions of the Work, wherever applicable to Mechanical Work.
B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

1.02 DESCRIPTION OF WORK
A. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and made ready for operation by the Owner, all coils as shown on the drawings and hereinafter specified.

1.03 QUALITY ASSURANCE
A. Manufacturing firms regularly engaged in manufacture of this material with characteristics and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years.
B. Provide product produced by the manufacturers, which are listed in Section 15600 "Approved Manufacturer's List".
C. Provide equipment whose performance, under specified conditions, is certified by the manufacturer.

1.04 SUBMITTALS
A. Refer to Section 01 31 46 - Special Requirements for Mechanical and Electrical Work and submit shop drawings.

1.05 COORDINATION
A. Refer to Section 01 31 46 - Special Requirements for Mechanical and Electrical Work.

1.06 GUARANTEE
A. Refer to Section 01 31 46 - Special Requirements for Mechanical and Electrical Work.
PART 2 - PRODUCTS

2.01 WATER COILS

A. All water coils shall be of the continuous flat plate fin type for minimum resistance to air flow. Fins shall be fabricated with drawn collars and shall be bonded to the tubes by a hydraulic expansion process. Openings in unit casing for coil connections to be sealed against leakage. Coil casings shall be not less than 16 gauge galvanized steel.

B. Water coils shall be of the continuous tube type and circuited so as to be completely drainable by gravity through the supply header. Headers and tubes are to be fabricated of a seamless .024 inch thick wall copper tubing. Fins are to be .009 inch thick aluminum for heating coils and .005 inch thick copper for cooling coils. Supply and return headers shall be complete enclosing within the unit casing or external where called for on the drawing, and shall be equipped with steel nipples of extra length equipped with drain and vent plugs outside unit casing. Coils shall have capacities as called for and shall have the minimum number of rows as shown on the schedule.

2.02 DIRECT EXPANSION COOLING COILS

A. Tubes - Round, seamless copper grooves, arranged in parallel pattern with respect to airflow.

B. Fins - Plat-Tube, Sigma-Flo II configured, copper fins producing identical capacities. Fins continuous across entire coil width and die-formed in multiple stages for accurate tube fit, fin bonding and spacing. Fins mechanically bonded to tubes for lasting reliability.

C. Casing - Continuous coated galvanized steel, 16 gauge formed end supports and top and bottom channels. %" holes on 3" centers in channels for mounting or fastening coils together. One 16 gauge continuous coated, galvanized steel center tube support on ordering lengths over 42". Two or more supports on lengths over 96".

D. Test and Working Pressure - Proof tested at 450 psig and leak tested at 300 psig air pressure under water, cleaned, dehydrated and sealed with dry nitrogen charge. Suitable for working pressures up to 250 psig.

E. U-Bends - Round, seamless copper tubes, %" O.D., machine die-formed on each end to provide accurate fit for silver brazed joints.

F. Distributor - Venture type refrigerant distributors or low pressure drop design, arranged for down feed. Male sweet connections. Maximum of twelve circuits per single distributor. Split evaporator.

G. Air Bypass and Water Carryover Arrestor - Foam sealing strip located between casing channels and fins along top and bottom.
PART 3 - EXECUTION

3.01  INSPECTION

   A.  Contractor shall examine location where this equipment is to be installed and determine space conditions and notify architect in writing of conditions detrimental to proper and timely completion of the work.

   B.  Do not proceed with the work until unsatisfactory conditions have been corrected.

3.02  INSTALLATION

   A.  Install coils where shown, in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that coils comply with requirements and serve intended purposes.

   B.  Coordinate with other work as necessary to interface installation of coils with other components of systems.

   C.  Check alignment and, where necessary (and possible), realign shafts of motors and coils within tolerances recommended by manufacturer.

3.03  FIELD QUALITY CONTROL

   A.  Upon completion of installation of coils, test coils to demonstrate compliance with requirement. When possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected. Refer to Section 23 05 93 - Testing and Balancing.

END OF SECTION 23 82 16
PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. This Section is to coordinate with and be complementary to the General Conditions and Supplementary General Conditions of the work, wherever applicable to Mechanical and Electrical Work.

B. Drawings are diagrammatic and are a graphic representation of contract requirements to the best available standards at the scale required.

C. Power systems riser diagrams, as well as schematic diagrams, generally indicate connections to be used for various systems and equipment. Systems conduit and wiring shall be as required for the actual systems installed on this Project. Provide all work shown on diagrams whether or not it is duplicated on the plans.

1.02 SCOPE OF WORK

A. The Specifications and the accompanying drawings are intended to secure the provisions of all material, labor, equipment, and services necessary to install complete, tested, and ready for operation the Electrical Systems in accordance with the Specifications and Drawings. All systems shall be complete with all necessary appurtenances and minor auxiliaries, including pull boxes, offsets to clear interferences, and supports which are not shown but are needed to make each system complete in every respect. All work described in the Specifications and not shown on the Drawings, or vice versa, shall be furnished in complete working order. If mention has been omitted of any item of work or material, necessary for completion of the system, then such items must be and are hereby included.


2. Raceways and installation components.

3. Wire and Cable.

4. Grounding system in conformance with applicable codes.

5. Wiring devices.

6. The Contractor shall be responsible for maintaining the fire resistance rating of any rated wall, ceiling or floor for which his work partially or fully penetrates. Work which could potentially penetrate or breach a rated wall, ceiling or floor include, but are not limited to flush-mounted recessed panel boards, conduit and pipe, ducts, equipment, supports or reinforcements. For any such situation, the Contractor shall provide the necessary fire stopping material, insulation or system in order to maintain the fire rating of the wall, ceiling or floor. The Contractor is responsible for reviewing the building construction drawings, including those of the architectural and structural trades, in order to determine the fire resistance ratings for the walls, floors and ceilings for which their work will partially or fully penetrate.

7. Cutting and core drilling associated with electrical work.

8. Prime painting, where required for electrical equipment and installation.
9. Removal of existing electrical work in accordance with Architectural Demolition Scheme or as directed and required. Restoration of electrical service in affected adjoining areas which are to continue to function.

10. Provision for temporary light and power.

11. Paying all fees as required by governing agency and performing all testing as required by governing agency and adjusting and furnishing all certificates of approval, and those of Underwriters.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. The following items of materials and labor will be furnished under other Sections of the Specifications and shall be excluded from the work to be furnished by this Contractor:

1. Rough and finish patching.

1.04 QUALITY ASSURANCE AND STANDARDS

A. The complete installation shall be in accordance with the applicable requirements and standards of National Electrical Manufacturers Association (NEMA), National Fire Protection Association (NFPA), National Electrical Code (NEC), Institute of Electrical and Electronic Engineers (IEEE), American National Standard Institute (ANSI), Occupational Safety and Health Administration (OSHA), National Electrical Safety Code, Insulated Cable Engineers Association (ICEA), Underwriters’ Laboratories (UL), Factory Mutual (FM), Factory Insurance Association (FIA), National Electrical Contractors Association (NECA) “Standard of Installation”, Local Inspection Agency, Local Power Company, Local Telephone Company, along with state and local municipal codes and all applicable codes and authorities having jurisdiction. Any items or requirements noted in the Specifications or on Drawings, which conflict with these shall be referred to the Architect for decision. All work necessary to comply with these requirements shall be performed by the Contractor at no extra cost to the Owner.

B. All electrical equipment, materials and appliances shall have the listing of the Underwriters’ Laboratories, Inc., and shall bear labels attesting to UL listing, and types approved by Municipal Departments having jurisdiction.

1.05 SUBMITTALS

A. The Contractor shall submit shop drawings with such promptness as to cause no delay in his own work or that of another contractor.

B. Submit shop drawings complete in every detail for items as described in the Contract Documents, or as may be required by the Architect.

C. Submit shop drawings as indicated in subsequent Sections of this Specification.

1.06 EXAMINATION OF EXISTING CONDITIONS ON PREMISES

A. Before submitting his bid, this Contractor shall visit the site of the work and shall thoroughly familiarize himself with the observable existing conditions affecting the work. No additional compensation will be granted on account of extra work made necessary by the Contractor's failure to investigate such existing conditions. Verify all grades, elevations, dimensions and clearances at the site.
B. Examine all work prepared by others to receive the work of this Section and report any discrepancies and/or defects affecting installation to the General Contractor for correction. Commencement of work will be construed as complete acceptance of preparatory work by others.

C. Existing conditions, equipment, material, and sizes are shown for reference only. Verify existing conditions and bring any discrepancies to Architect's attention in writing prior to submission.

1.07 REMOVAL AND RELOCATION OF EXISTING WORK

A. Disconnect, remove and/or relocate electrical material, equipment, devices, components, and other work noted and required by demolition or alterations in existing construction.

B. Provide new material and equipment required for relocated equipment.

C. Remove conductors from existing raceways to be rewired. Clean raceways as required prior to rewiring.

D. Tape both ends of abandoned conductors, and cap outlets and abandoned raceways.

E. Cut and cap abandoned floor raceways flush with concrete floor or behind walls and ceilings.

F. Dispose of removed raceways and wiring.

G. Dispose of removed electrical equipment as directed.

H. All electrical work in adjoining areas which is indicated on the Drawings to continue to function but is affected by demolition work shall be reconnected and restored to present function as part of the electrical system of the Buildings.

I. Connect new work to existing work in a neat and acceptable manner, with minimum interference to existing facilities.

J. Maintain continuous operation of existing facilities affected by the work.

K. Alarm and emergency systems are to be interrupted only with the written consent of the Owner.

L. Temporary shutdowns when required, to be made only with written consent of Owner at times not to interfere with normal operations.

M. Where indicated on the Drawings or required by the alteration scheme, the Contractor shall remove all electrical outlets, switches, and other devices, complete with associated wiring, conduit, etc., from partitions, walls, and floors that are to be removed. When the removal of these makes dead electrical wiring that is to remain, Contractor shall install junction boxes or other devices necessary to make the circuits affected continuous and ready for operation. Otherwise, wiring shall be removed back to the nearest electrical outlet box that is to remain, or to the panelboard.

N. All raceways which become exposed beyond finished surfaces because of the alteration work shall be removed and rerouted behind finished surfaces.
O. Wiring that is to be removed as a result of demolition work, but is required to continue to function, shall be interrupted at convenient locations, rerouted (new wiring and conduits) and reconnected for continuation of their original function. New wiring extensions shall match existing ones in all respects, conductor ampacity, conduit size, etc.

1.08  COORDINATION OF WORK WITH OTHER TRADES

A. The work of this Section shall be coordinated with the work of all other Contracts and shall be so arranged that there will be no delay in the proper installation and completion of any part or parts of each respective work wherein it may be interrelated with that of this Contract so that generally all construction work can proceed in its natural sequence without unnecessary delay. All communications of a coordinating nature to the Architect shall be via the Construction Manager or General Contractor.

B. Examine all Architectural, Structural, Heating, Ventilating and Air Conditioning, Sprinkler and Plumbing Drawings relating to this Project, and verify all governing conditions at the site and become fully informed as to the extent and character of the work required and its relation to other work in the building. No consideration will be granted for any alleged misunderstanding of the materials to be furnished for work to be done.

C. Scaled and figured dimensions with respect to the items are approximate only; sizes of equipment have been taken from typical equipment items of the class indicated. Before proceeding with work, the Contractor shall carefully check all dimensions and sizes and shall assume full responsibility for the fitting-in of equipment and materials to the building and to meet architectural and structural conditions.

D. Coordinate work with other disciplines. Confer with other contractors whose work might affect this installation; and arrange all parts of this work and equipment in proper relation to the work and equipment of others, with the building construction and with architectural finish so that this work will harmonize in service, appearance, and function.

E. Exposed piping shall be installed to provide the maximum amount of headroom but in no case shall piping be installed less than seven feet (8'-0'') above the finished floor. Piping installed in areas where hung ceilings or other furred spaces are indicated shall be installed concealed.

F. The Contractor is referred to the Architectural Drawings for locations and types of hung ceilings and furred spaces.

1.09  INSPECTION AND TESTS

A. At the time of the final inspection and tests, all connections at the panelboards and all splices, etc., must have been completed. Each entire wiring system must test free from short circuits and grounds. When wiring systems are "megger" tested, the insulation resistance between conductors and between conductors and grounds, based on maximum load, shall not be less than that required by National Electrical Code and local authorities having jurisdiction. A written record of all test data shall be supplied to the Architect (five copies). The tests shall cover but not be limited to the following:
1. Electrical distribution system.
2. Any part of the work called for in the Specifications, or Drawings and as designated by the Architect or Engineers.
B. Provide all necessary testing equipment, instruments, and skilled personnel for the tests. If in the opinion of the Architect, the results of such tests show that the work has not complied with the requirements of the Specifications or Drawings, the Contractor shall make all additions or changes necessary to put the system in proper working condition and shall pay for all the expenses and for all subsequent tests which are necessary to determine whether the work is satisfactory. Any additional work or subsequent tests shall be carried out at the convenience of the Owner, prior to final payment.

1.10 PERMITS, CERTIFICATES AND FEES

A. Obtain and deliver a final Certificate of Approval from the applicable inspection authority having jurisdiction. Make delivery to the Architect for transmittal to the Owner upon completion of the work and before final payment. Pay all charges made by the inspection authority and include their cost in the bid.

B. This work shall include the procurement of and payment for all permits, certificates and fees for the performance of the electrical work in compliance with codes, applicable laws and municipal regulations including those from local utilities for services.

1.11 PROTECTION, MAINTENANCE AND PRODUCT HANDLING OF ELECTRICAL EQUIPMENT

A. Electrical equipment shall be delivered and stored at the site, properly packed and crated until finally installed. Store materials in spaces as designated by the General Contractor. Investigate each space through which equipment must be moved. If necessary, equipment shall be shipped from manufacturer in crated sections of size suitable for moving through restricted spaces.

B. Uninstalled and installed equipment and materials shall be adequately protected against loss or stealing; damage caused by water, paint, fire, plaster, moisture, acids, fumes, dust or other environmental conditions; or physical damage, during delivery, storage, installation and shutdown conditions. This Contractor shall replace any damage or stolen material without extra cost to the Owner.

C. Provide effective protection for all material and equipment against damage that may be caused by environmental conditions. Do no work when conditions of temperature in area or moisture on materials or substrates are not in accordance with material manufacturer's recommended conditions for installation.

D. This Contractor shall be responsible for the maintenance of all equipment and systems installed, until final acceptance by the Architect and the Owner. The Operation of the equipment by the Owner does not constitute an acceptance of the work. Work will be accepted only after the Contractor has adjusted his equipment, demonstrated that it fulfills the requirements of the Drawings and Specifications, and has furnished all required certificates.

E. This Contractor shall guarantee in writing to the Owner that all work installed by him shall be free of defects in workmanship and materials and that all apparatus will develop the capacities and characteristics as indicated, and that, if during a period of one year from date of final approval of work by the Architect, any defects in workmanship, materials or performance appear, he will remedy them without any cost to the Owner. Guarantee requirements shall consist of the aforementioned and other requirements, as established under applicable Contract Documents.
F. Provide effective protection against damage for all material and equipment during shipment, and storage at the Project Site. Cover all stored equipment to exclude dust and moisture. Place stored conduit on dunnage with appropriate weather cover and caps on exposed ends.

G. After cabinets and boxes are installed, cover openings to prevent entrance of water and foreign materials. Close conduit openings with temporary metal or plastic caps, including those terminated in cabinets.

H. Protect all rough and finished floors and other finished surfaces from damage which may be caused by construction materials and methods. Protect floors with tarpaulins, chip pans and oil-proof floor covering. Protect finished surfaces from welding and cutting splatters with baffles and asbestos splatter blankets. Protect finished surfaces from paint droppings, adhesive and other marring agents with drop cloths. Protect other surfaces with appropriate protective measures.

I. Have materials delivered to site. Unload and store materials in designated location, and protect from damage. Deliver materials to their point of installation.

J. Deliver materials to Project site in manufacturer's original unopened containers with manufacturer's name and product identification clearly marked thereon.

1.12 ACCESSIBILITY AND MEASUREMENTS

A. All work shall be installed so as to be readily accessible for operation, maintenance and repair. Minor deviations from the plans may be made to accomplish this, subject to the approval or the Architect or Engineers.

B. Before ordering any material or doing any work, the Contractor shall verify all measurements at the Building, and shall be responsible for the correctness of same as related to the work under this Contract.

1.13 TEMPORARY LIGHT AND POWER

A. Electric services for temporary light and power shall be obtained from the nearest existing panelboard and extended as required. Consult the Hospital Engineer prior to making any connections to existing services.

B. The Electrical Contractor shall furnish, install and maintain the temporary lighting and power system for all Contractors in the area of work. The use of electricity shall be kept to a minimum.

C. The Owner or Owner's Representative will pay for all energy required by the temporary lighting and power system.

D. Provide all wiring, supports, lamp sockets, receptacle sockets and any other materials, supplies or equipment necessary for temporary light and power system.

E. Ground fault protection required by OSHA for temporary receptacle circuits shall be accomplished by providing branch circuit panels containing ground fault protection branch circuit breakers.
F. Provide a grounding conductor connection to each receptacle grounding terminal. Minimum size branch circuit and grounding conductors shall be No. 12 AWG.

G. Install separate stringer circuits for lighting and receptacles. Each lamp socket shall be provided with a 100 watt lamp. Replace burned out lamps as required for as long as the temporary lighting system is maintained in operation.

H. Provide sufficient supplementary temporary lighting to permit proper execution of the work. This supplementary lighting shall consist of but not be limited to the following:
   1. Interior rooms not covered with general construction area lighting.

I. Keep the temporary lighting and power system operational commencing fifteen (15) minutes before the established starting time of that trade which starts work earliest in the morning and ending fifteen (15) minutes after the established quitting time of that trade which stops work latest in the evening. This applies to all weekdays, Monday through Friday inclusive, which are established as regular working days for any trade engaged in the work, and shall continue until Final Acceptance of the work or until these services are ordered terminated by the Owner or the Owner's Representative.

1.14 MATERIAL AND WORKMANSHIP

A. All material shall be new and of the best quality and shall have the Underwriters Laboratories label attached. The label shall be of the type for the intended application. The work throughout shall be executed in the best and most thorough manner under the direction of, and to the satisfaction of the Architect who will interpret the meaning of the Drawings and Specifications. The Architect shall have the power to reject any work and materials which, in his opinion, is not in full accordance therewith.

B. If, after installation, operation of the equipment proves to be unsatisfactory to the Owner by reason of defects, errors or omissions, the Owner reserves the right to operate equipment until it can be removed from service for correction by Contractor. Contractor shall pay for damages to work of other trades caused by this defective equipment and its replacement.

1.15 OPERATING INSTRUCTIONS (SYSTEMS AND EQUIPMENT FURNISHED UNDER CONTRACT FOR ELECTRICAL WORK)

A. Two months prior to the completion of all work and the final inspection of the installation by the Hospital, five copies of a complete Instruction Manual, bound in booklet form and suitably indexed, shall be submitted to the Architect for approval. All written material contained in the Manual shall be typewritten or printed.

B. The Manual shall contain the following items:
   1. Table of Contents
   3. Description of system or equipment.
      a. Complete schematic drawings of all systems.
      b. Functional and sequential description of all systems.
   4. Systems Operation
      a. Operation procedures.
      b. All posted instruction charts.
5. Maintenance
   a. Systems trouble-shooting charts
   b. Procedures for checking out functions.
   c. Recommended list of spare parts.

6. Listing of Manufacturers

7. Manufacturer's Data (where multiple model, type and size listings are included, clearly and conspicuously indicate those that are pertinent to this installation.
   a. Description - literature, drawings, illustrations, certified performance charts, technical data, etc.
   b. Operation
   c. Maintenance - including complete trouble-shooting charts
   d. Parts list
   e. Names, addresses and telephone numbers of recommended repair and service companies.
   f. Guarantee data.

END OF SECTION 260512
SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:
   1. Section 260523 "Control-Voltage Electrical Power Cables" for control systems
      communications cables and Classes 1, 2 and 3 control cables.
   2. Section 271500 "Communications Horizontal Cabling" for cabling used for voice and
      data circuits.

1.03 DEFINITIONS

A. VFC: Variable frequency controller.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.06 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.01 CONDUCTORS AND CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the
following:
   1. Alcan Products Corporation; Alcan Cable Division.
2. Alpha Wire.
3. Belden Inc.
5. General Cable Technologies Corporation.

B. **Copper** Conductor: Comply with NEMA WC 70/ICEA S-95-658.

C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for **Type THHN-2-THWN-2 and Type SO**.

D. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for **armored cable, Type AC metal-clad cable, Type MC Type SO** with ground wire.

E. VFC Cable:
   1. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable.
   2. Type TC-ER with oversized crosslinked polyethylene insulation, [spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire] [dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires], and sunlight- and oil-resistant outer PVC jacket.
   3. Comply with UL requirements for cables in Classes I and II, Division 2 hazardous location applications.

2.02 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, **provide products by one of the following:**
   1. AFC Cable Systems, Inc.
   2. Gardner Bender.
   4. Ideal Industries, Inc.
   5. Ilsco; a branch of Bardes Corporation.
   6. NSi Industries LLC.
   7. O-Z/Gedney; a brand of the EGS Electrical Group.
   8. 3M; Electrical Markets Division.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.03 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.
PART 3 - EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: **Copper**. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for **No. 10 AWG** and smaller; stranded for **No. 8 AWG** and larger, except VFC cable, which shall be extra flexible stranded.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders: **Type THHN-2-THWN-2, single conductors in raceway Armored cable, Type AC.**

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: **Type THHN-2-THWN-2, single conductors in raceway Armored cable, Type AC.**

C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: **Type THHN-2-THWN-2, single conductors in raceway Underground feeder cable, Type UF.**

D. Exposed Branch Circuits, Including in Crawlspace: **Type THHN-2-THWN-2, single conductors in raceway Armored cable, Type AC.**

E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: **Type THHN-2-THWN-2, single conductors in raceway Armored cable, Type AC.**

F. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

G. VFC Output Circuits: **Type XHHW-2 in metal conduit with braided shield.**

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. 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.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

G. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.04 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-486B.

B. Make splices, terminations, 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, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) [12 inches (300 mm)] of slack.

3.05 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.06 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.07 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.08 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
1. After installing conductors and cables and before electrical circuitry has been energized, test feeder conductors for compliance with requirements.


3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
   a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
   b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Test and Inspection Reports: Prepare a written report to record the following:
   1. Procedures used.
   2. Results that comply with requirements.
   3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

E. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 26 05 19
SECTION 260523
CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

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

1.02 SUMMARY
A. Section Includes:
   1. Multimode optical-fiber cabling.
   2. UTP cabling.
   3. RS-485 cabling.
   4. Low-voltage control cabling.
   5. Control-circuit conductors.
   6. Identification products.

1.03 DEFINITIONS
A. EMI: Electromagnetic interference.
B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
C. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
D. RCDD: Registered Communications Distribution Designer.
E. UTP: Unshielded twisted pair.

1.04 ACTION SUBMITTALS
A. Product Data: For each type of product.

1.05 INFORMATIONAL SUBMITTALS
A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
B. Source quality-control reports.
C. Field quality-control reports.
1.06  QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to
      supervise on-site testing.

PART 2 - PRODUCTS

2.01  SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by
   a qualified testing agency, and marked for intended location and application.

2.02  PERFORMANCE REQUIREMENTS

A. Flame Travel and Smoke Density in Plenums: As determined by testing identical products
   according to NFPA 262 by a qualified testing agency. Identify products for installation in
   plenums with appropriate markings of applicable testing agency.
   1. Flame Travel Distance: 60 inches (1520 mm) or less.
   2. Peak Optical Smoke Density: 0.5 or less.
   3. Average Optical Smoke Density: 0.15 or less.

B. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As
determined by testing identical products according to UL 1666.

C. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum
   Building Spaces: As determined by testing identical products according to UL 1685.

2.03  BACKBOARDS

A. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440
   mm). Comply with requirements for plywood backing panels in Section 061000 "Rough
   Carpentry."

B. Painting: Paint plywood on all sides and edges with flat eggshell latex paint. Comply with
   requirements in Section 099123 "Interior Painting."

2.04  OPTICAL-FIBER CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the
   following:
   1. Belden Inc.
   2. CommScope, Inc.
   3. Corning Incorporated.
   4. Emerson Connectivity Solutions.
   5. General Cable Technologies Corporation.
   7. Nexans; Berk-Tek Products.
8. **Siemon Company (The).**
9. **Superior Essex Inc.**
10. **SYSTIMAX Solutions:** a CommScope, Inc. brand.
11. **3M.**
12. **Tyco Electronics/AMP Netconnect:** Tyco International Ltd.

B. **Description:** Multimode, 62.5/125-micrometer, 24-fiber, nonconductive, tight-buffer, optical-fiber cable.
   1. Comply with ICEA S-83-596 for mechanical properties.
   2. Comply with TIA-568-C.3 for performance specifications.
   3. Comply with TIA-492AAAA-B for detailed specifications.
   4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
      a. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
      b. General Purpose, Nonconductive: Type OFN, Type OFNG, Type OFNP, or Type OFNR in listed communications raceway.
   5. Maximum Attenuation: **3.5 dB/km at 850 nm; 1.5 dB/km at 1300 nm.**
   6. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

C. **Jacket:**
   2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
   3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed **40 inches (1000 mm).**

2.05 **OPTICAL-FIBER CABLE HARDWARE**

A. **Manufacturers:** Subject to compliance with requirements, **provide products by one of the following:**
   1. **ADC.**
   2. **American Technology Systems Industries, Inc.**
   3. **Belden Inc.**
   4. **Corning Incorporated.**
   5. **Dynacom Inc.**
   6. **Hubbell Incorporated.**
   7. **Molex Premise Networks:** a division of Molex, Inc.
   8. **Panduit Corp.**
   9. **Siemon Company (The).**

B. **Cross-Connects and Patch Panels:** Modular panels housing multiple-numbered, duplex cable connectors.
   1. Number of Connectors per Field: **One** for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

C. **Patch Cords:** Factory-made, dual-fiber cables in **36-inch (900-mm)** lengths.

D. **Cable Connecting Hardware:**
2. Quick-connect, simplex and duplex, [Type SC] [Type ST] [Type LC] [Type MT-RJ] connectors. Insertion loss of not more than 0.75 dB.
3. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.06 UTP CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ADC.
   2. Alpha Wire Company; a division of Belden Inc.
   3. Belden Inc.
   4. CommScope, Inc.
   5. Draka Cableteq USA.
   7. Mohawk; a division of Belden Inc.
   8. Nexans; Berk-Tek Products.
   9. Siemon Company (The).
   10. Superior Essex Inc.
   11. SYSTIMAX Solutions; a CommScope, Inc. brand.
   12. 3M.
   13. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: 100-ohm, four-pair UTP.
   2. Comply with TIA-568-C.1 for performance specifications.
   4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with NEMA WC 66, UL 444 and NFPA 70 for the following types:
      a. Communications, Riser Rated: Type CMR complying with UL 1666[ and ICEA S-103-701].
      b. Communications, General Purpose: Type CM or Type CMG[; or Type CM, Type CMG, Type CMP, or Type CMR in listed communications raceways].

2.07 UTP CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ADC.
   3. Belden Inc.
   4. Dynacom Inc.
   5. Hubbell Incorporated.
   6. Leviton Commercial Networks Division.
   7. Molex Premise Networks; a division of Molex, Inc.
   8. Panduit Corp.
   9. Siemon Company (The).
   10. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks: **110-style IDC for Category 6.** Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.  
1. Number of Terminals per Field: **One** for each conductor in assigned cables.

E. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.  
1. Number of Jacks per Field: One for each four-pair UTP cable indicated.

F. Jacks and Jack Assemblies: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-C.1.

G. Patch Cords: Factory-made, four-pair cables in **36-inch (900-mm) lengths;** terminated with eight-position modular plug at each end.  
1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.  
2. Patch cords shall have color-coded boots for circuit identification.

H. Workstation Outlets: **Four-port-connector assemblies mounted in multigang faceplate.**

I. Faceplates:  
1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."  
   a. Flush-mounted jacks, positioning the cord at a 45-degree angle.

J. Legend:  
1. Machine printed, in the field, using adhesive-tape label.

2.08 TWIN-AXIAL DATA HIGHWAY CABLE

A. Standard Cable: NFPA 70, Type CM.  
1. Paired, four pairs, No. 22 AWG, stranded **7x30** tinned-copper conductors.  
2. Polypropylene insulation.  
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.  
4. PVC jacket.  
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.  
2.09 CONTROL-CIRCUIT CONDUCTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Encore Wire Corporation.
   2. General Cable Technologies Corporation.

B. Class 1 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 44.

C. Class 2 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 44.

D. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 44.

2.10 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP cables according to TIA-568-C.2.

C. Factory test optical-fiber cables according to TIA-568-C.3.

D. Cable will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Test cables on receipt at Project site.
   1. Test optical-fiber cable to determine the continuity of the strand end to end. Use optical-fiber flashlight or optical loss test set.
   2. Test optical-fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
   3. Test each pair of UTP cable for open and short circuits.

3.02 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.
   1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
2. Outlet boxes for optical-fiber cables shall be no smaller than 4 inches (102 mm) square by [1-1/2 inches (38 mm)] [2-1/8 inches (53 mm)] deep with extension ring sized to bring edge of ring to within 1/8 inch (3.1 mm) of the finished wall surface.

3. Flexible metal conduit shall not be used.

B. Comply with TIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.

C. Install manufactured conduit sweeps and long-radius elbows if possible.

D. Raceway Installation in Equipment Rooms:
   1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
   2. Install cable trays to route cables if conduits cannot be located in these positions.
   3. Secure conduits to backboard if entering the room from overhead.
   4. Extend conduits [3 inches (75 mm)] <Insert dimension> above finished floor.
   5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

E. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1 and NFPA 70.

B. General Requirements for Cabling:
   2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems."
   3. Terminate all conductors and optical fibers; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
   4. Cables may not be spliced.
   5. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Install lacing bars and distribution spools.
   7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
10. Support: Do not allow cables to lay on removable ceiling tiles.
11. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.

C. UTP Cable Installation:
   2. Install termination hardware as specified in Section 271500 "Communications Horizontal Cabling" unless otherwise indicated.
   3. Do not untwist UTP cables more than 1/2 inch (12 mm) at the point of termination to maintain cable geometry.

D. Installation of Control-Circuit Conductors:
   1. Install wiring in raceways. Comply with requirements specified in Section 260533 "Raceways and Boxes for Electrical Systems."

E. Optical-Fiber Cable Installation:
   2. Terminate cable on connecting hardware that is rack or cabinet mounted.

F. Separation from EMI Sources:
   1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.
   2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
      a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
      b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 12 inches (305 mm).
      c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
   3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
      a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
      b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
      c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 12 inches (305 mm).
   4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
      a. Electrical Equipment or Circuit Rating Less Than 2 kVA: No requirement.
      b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.04 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:
1. Class 1 remote-control and signal circuits; No 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG.

3.05 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."
B. Comply with TIA-569-B, Annex A, "Firestopping."
C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.06 GROUNDING

A. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
B. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.07 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
B. Identify data and communications system components, wiring, and cabling according to TIA-606-A; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.

3.08 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
C. Perform the following tests and inspections:
   1. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
2. Test UTP cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross-connection.

3. Optical-Fiber Cable Tests:
   a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   b. Link End-to-End Attenuation Tests:
      1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
      2) Attenuation test results for links shall be less than 2.0 dB.

D. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 26 05 23
PART 1 - GENERAL

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

1.02 SUMMARY
A. Section includes grounding and bonding systems and equipment.
B. Section includes grounding and bonding systems and equipment, plus the following special applications:
   1. Ground bonding common with lightning protection system.

1.03 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.

1.04 INFORMATIONAL SUBMITTALS
A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
   1. Grounding arrangements and connections for separately derived systems.
B. Qualification Data: For testing agency and testing agency's field supervisor.
C. Field quality-control reports.

1.05 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. Instructions for periodic testing and inspection of grounding features at test wells ground rings grounding connections for separately derived systems based on NFPA 70B.
         1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
         2) Include recommended testing intervals.
1.06 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Burndy; Part of Hubbell Electrical Systems.
   2. ERICO International Corporation.
   3. O-Z/Gedney; A Brand of the EGS Electrical Group.

2.02 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.03 CONDUCTORS

A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
   4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
   5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
   6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
   7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
2.04 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

PART 3 - EXECUTION

3.01 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Install bus horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
   2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

C. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Connections to Structural Steel: Welded connectors.

3.02 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
   1. Feeders and branch circuits.
   2. Lighting circuits.
   3. Receptacle circuits.
   5. Three-phase motor and appliance branch circuits.

3.03 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
B. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.04 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:
   1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
   2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

E. Report measured ground resistances that exceed the following values:
   1. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
   2. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 05 26
SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

B. Related Sections include the following:
   1. Section 260548.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.03 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.04 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

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

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.05 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Steel slotted support systems.
2. Nonmetallic slotted support systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
   1. Trapeze hangers. Include Product Data for components.
   2. Steel slotted channel systems. Include Product Data for components.
   3. Nonmetallic slotted channel systems. Include Product Data for components.
   4. Equipment supports.

1.06 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.07 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.08 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified together with concrete Specifications.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

PART 2 - PRODUCTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allied Tube & Conduit.
      b. Cooper B-Line, Inc.
      c. ERICO International Corporation.
      d. GS Metals Corp.
      e. Thomas & Betts Corporation.
      f. Unistrut; Atkore International.
      g. Wesanco, Inc.
   2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
   3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.

5. Channel Dimensions: Selected for applicable load criteria.

B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- (14-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c., in at least 1 surface.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allied Tube & Conduit.
      b. Cooper B-Line, Inc.
      c. Fabco Plastics Wholesale Limited.
      d. Seasafe, Inc.
   2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
   3. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
   4. Rated Strength: Selected to suit applicable load criteria.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
   1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Hilti, Inc.
         2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
         3) MKT Fastening, LLC.
         4) Simpson Strong-Tie Co., Inc.
   2. Mechanical-Expansion Anchors: Insert-wedge-type, [zinc-coated] [stainless] steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Cooper B-Line, Inc.
2) Empire Tool and Manufacturing Co., Inc.
3) Hilti, Inc.
4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.

2.02 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.01 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.02 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

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

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

3.04 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033053 "Miscellaneous Cast-in-Place Concrete."

C. Anchor equipment to concrete base.
1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.05 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Comply with requirements in Section 099123 "Interior Painting" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

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

END OF SECTION 260529
PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Metal conduits, tubing, and fittings.
   2. Metal wireways and auxiliary gutters.

1.03 DEFINITIONS

A. ARC: Aluminum rigid conduit.
B. GRC: Galvanized rigid steel conduit.
C. IMC: Intermediate metal conduit.

1.04 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings and cabinets.
B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and
   attachment details.
C. Samples: For wireways and surface raceways and for each color and texture specified, 12 inches
   (300 mm) long.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items
   are shown and coordinated with each other, using input from installers of items involved:
   1. Structural members in paths of conduit groups with common supports.
B. Seismic Qualification Certificates: For enclosures, cabinets, and conduit racks and their
   mounting provisions, including those for internal components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of
      assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate
      and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

C. Source quality-control reports.

PART 2 - PRODUCTS

2.01 METAL CONDUITS, TUBING, AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Allied Tube & Conduit.
   2. O-Z/Gedney.
   3. Republic Conduit.
   5. Thomas & Betts Corporation.
   6. Western Tube and Conduit Corporation.
   7. Wheatland Tube Company.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. ARC: Comply with ANSI C80.5 and UL 6A.

E. IMC: Comply with ANSI C80.6 and UL 1242.

F. EMT: Comply with ANSI C80.3 and UL 797.

G. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
   1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
   2. Fittings for EMT:
      a. Material: Steel.
      b. Type: Setscrew.
   3. Expansion Fittings: Steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

H. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.
2.02 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper B-Line, Inc.
   2. Hoffman.
   4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 3R and Type 12 unless otherwise indicated, and sized according to NFPA 70.
   1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, 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. Wireway Covers: Flanged-and-gasketed type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.03 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Prime coated, ready for field painting.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Mono-Systems, Inc.
      b. Panduit Corp.
      c. Wiremold / Legrand.

2.04 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. EGS/Appleton Electric.
   2. Erickson Electrical Equipment Company.
   3. Hoffman.
   5. O-Z/Gedney.
   6. RACO; Hubbell.
   7. Thomas & Betts Corporation.
   8. Wiremold / Legrand.

B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

D. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.

E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

F. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

G. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).

H. Gangable boxes are allowed.

I. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 3R Type 12 with continuous-hinge cover with flush latch unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
   2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

J. Cabinets:
   1. NEMA 250, Type 3R Type 12 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
   2. Hinged door in front cover with flush latch and concealed hinge.
   3. Key latch to match panelboards.
   4. Metal barriers to separate wiring of different systems and voltage.
   5. Accessory feet where required for freestanding equipment.

2.05 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
   1. Tests of materials shall be performed by an independent testing agency.
   2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
   3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.01 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed Conduit: GRC IMC.
   2. Concealed Conduit, Aboveground: GRC IMC EMT.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT or RNC.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC.
   a. Loading dock.

C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

G. Install surface raceways only where indicated on Drawings.

3.02 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. 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.

C. Complete raceway installation before starting conductor installation.

D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.
G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inches (300 mm) of enclosures to which attached.

I. Raceways Embedded in Slabs:
   1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot (3-m) intervals.
   2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
   3. Arrange raceways to keep a minimum of [1 inch (25 mm)] [2 inches (50 mm)] of concrete cover in all directions.
   4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

J. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

K. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

L. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

M. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35-mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

N. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

O. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

P. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

Q. 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. Cap underground raceways designated as spare above grade alongside raceways in use.

R. Surface Raceways:
   1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
   2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway.
section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

S. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

T. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
   1. Where otherwise required by NFPA 70.

U. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

V. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

W. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

X. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

Y. Locate boxes so that cover or plate will not span different building finishes.

Z. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

AA. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.03 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.04 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.  
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION 26 05 33
SECTION 26 05 44
SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
   2. Sleeve-seal systems.
   5. Silicone sealants.

B. Related Requirements:
   1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:
   1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.
   2. Laboratory Test Reports for Credit EQ 4: For sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

PART 2 - PRODUCTS

2.01 SLEEVES

A. Wall Sleeves:
   2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

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

F. Sleeves for Rectangular Openings:
   2. Minimum Metal Thickness:
      a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
      b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.02 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Advance Products & Systems, Inc.
      b. CALPICO, Inc.
      c. Metraflex Company (The).
      d. Pipeline Seal and Insulator, Inc.
      e. Proco Products, Inc.
   2. Sealing Elements: EPDM rubber 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.
   4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.03 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Presealed Systems.
2.04 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.


C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.05 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
   1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
   2. Sealant shall have VOC content of ** g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.01 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
   1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
      a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
      b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
   2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
   3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.

5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
   1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
   2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel [cast-iron] pipe 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.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.02 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.03 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 26 05 44
PART 1 - GENERAL

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

1.02 SUMMARY
   A. Section Includes:
      1. Identification for raceways.
      2. Identification of power and control cables.
      3. Identification for conductors.
      4. Warning labels and signs.
      5. Equipment identification labels.

1.03 ACTION SUBMITTALS
   A. Product Data: For each electrical identification product indicated.
   B. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting
      provisions, and graphic features of identification products.
   C. Identification Schedule: An index of nomenclature of electrical equipment and system
      components used in identification signs and labels.

1.04 QUALITY ASSURANCE
   A. Comply with ANSI A13.1.
   B. Comply with NFPA 70.
   D. Comply with ANSI Z535.4 for safety signs and labels.
   E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks
      used by label printers, shall comply with UL 969.

1.05 COORDINATION
   A. Coordinate identification names, abbreviations, colors, and other features with requirements in
      other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's

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

C. Coordinate installation of identifying devices with location of access panels and doors.

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

PART 2 - PRODUCTS

2.01 POWER AND CONTROL RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:
   1. Black letters on an orange field.
   2. Legend: Indicate voltage.

C. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.

D. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
   1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
   2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.02 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.

B. Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.
C. Self-Adhesive, Self-Laminating Polyester Labels: Write-on, 3-mil- (0.08-mm-) thick flexible label with acrylic pressure-sensitive adhesive that provides a clear, weather- and chemical-resistant, self-laminating, protective shield over the legend. Labels sized to fit the cable diameter such that the clear shield overlaps the entire printed legend.


E. Write-On Tags: Polyester tag, [0.010 inch (0.25 mm)] [0.015 inch (0.38 mm)] thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable. 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

F. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of cable it identifies and to stay in place by gripping action.

2.03 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.

B. Self-Adhesive, Self-Laminating Polyester Labels: Write-on, 3-mil- (0.08-mm-) thick flexible label with acrylic pressure-sensitive adhesive that provides a clear, weather- and chemical-resistant, self-laminating, protective shield over the legend. Labels sized to fit the conductor diameter such that the clear shield overlaps the entire printed legend.

C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of conductor it identifies and to stay in place by gripping action.


E. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

F. Write-On Tags: Polyester tag, [0.010 inch (0.25 mm)] [0.015 inch (0.38 mm)] thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable. 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer. 2. Labels for Tags: Self-adhesive label, machine-printed with permanent, waterproof, black ink recommended by printer manufacturer, sized for attachment to tag.

2.04 FLOOR MARKING TAPE

A. 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.
2.05 WARNING LABELS AND SIGNS


B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:
   1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
   2. 1/4-inch (6.4-mm) grommets in corners for mounting.
   3. Nominal size, 7 by 10 inches (180 by 250 mm).

2.06 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. inches (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
   1. Engraved legend with black letters on white face.
   2. Punched or drilled for mechanical fasteners.
   3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).

2.07 EQUIPMENT IDENTIFICATION LABELS

A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).

2.08 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape with adhesive appropriate to the location and substrate.

G. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

H. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

I. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.02 IDENTIFICATION SCHEDULE

A. Accessible Raceways, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Identify with self-adhesive vinyl tape applied in bands. Install labels at 10-foot (3-m) maximum intervals.

B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
   2. Power.

C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, use color-coding conductor tape to identify the phase.
   1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded feeder and branch-circuit conductors.
      a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
      b. Colors for 208/120-V Circuits:
         1) Phase A: Black.
         2) Phase B: Red.
         3) Phase C: Blue.
      c. Colors for 277/408-V Circuits:
         1) Yellow
         2) Brown
         3) Orange
d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum 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. Locate bands to avoid obscuring factory cable markings.

D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

E. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use write-on tags with the conductor or cable designation, origin, and destination.

F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
   2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

G. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.
   2. Identify system voltage with black letters on an orange background.
   3. Apply to exterior of door, cover, or other access.
   4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
      a. Power transfer switches.
      b. Controls with external control power connections.

H. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

I. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
   1. Labeling Instructions:
      a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
      b. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
c. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment to Be Labeled:
   a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved, laminated acrylic or melamine label.
   b. Enclosures and electrical cabinets.
   c. Access doors and panels for concealed electrical items.
   d. Emergency system boxes and enclosures.
   e. Enclosed switches.
   f. Enclosed circuit breakers.
   g. Enclosed controllers.
   h. Variable-speed controllers.
   i. Push-button stations.
   j. Remote-controlled switches, dimmer modules, and control devices.

END OF SECTION 26 05 53
PART 1 - GENERAL

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

1.02 SUMMARY
A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.03 DEFINITIONS
A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
D. SCCR: Short-circuit current rating.
E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.04 ACTION SUBMITTALS
A. Product Data: For computer software program to be used for studies.
B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
   1. Short-circuit study input data, including completed computer program input data sheets.
   2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
      a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.
b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

1.05 INFORMATIONAL SUBMITTALS
   A. Qualification Data: For Short-Circuit Study Specialist.
   B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.06 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 unacceptable.
   B. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.01 COMPUTER SOFTWARE
   A. Software Developers: Subject to compliance with requirements, provide software by one of the following:
      1. ESA Inc.
      2. Operation Technology, Inc.
      3. Power Analytics, Corporation.
      4. SKM Systems Analysis, Inc.
   B. Comply with IEEE 399 and IEEE 551.
   C. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
   D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.02 SHORT-CIRCUIT STUDY REPORT CONTENTS
   A. Executive summary.
   B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.
   C. One-line diagram, showing the following:
1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Comments and recommendations for system improvements, where needed.

E. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.


G. Short-Circuit Study Output:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
   a. Voltage.
   b. Calculated fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. Equivalent impedance.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
   a. Voltage.
   b. Calculated symmetrical fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. Calculated asymmetrical fault currents:
      1) Based on fault-point X/R ratio.
      2) Based on calculated symmetrical value multiplied by 1.6.
      3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Obtain all data necessary for the conduct of the study.

1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.
2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For equipment that is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for Project's overcurrent protective devices 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. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
5. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
6. Motor horsepower and NEMA MG 1 code letter designation.
7. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.02 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.
B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:
   1. To normal system low-voltage load buses where fault current is 10 kA or less.
   2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
   1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:
   1. Electric utility's supply termination point.
   2. Low-voltage switchgear.
   3. Control panels.
   4. Standby generators and automatic transfer switches.
   5. Branch circuit panelboards.
   6. Disconnect switches.

3.03 ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

3.04 DEMONSTRATION

A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION 260572
PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1. Study results shall be used to determine coordination of series-rated devices.

1.03 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.04 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and equipment evaluation reports.
3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.
a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Coordination Study Specialist.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. The following parts from the Protective Device Coordination Study Report:

   1) One-line diagram.
   2) Protective device coordination study.
   3) Time-current coordination curves.

b. Power system data.

1.07 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 unacceptable.

B. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.01 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers: Subject to compliance with requirements, provide software by one of the following:

1. ESA Inc.
2. Operation Technology, Inc.
3. Power Analytics, Corporation.
4. SKM Systems Analysis, Inc.

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:
   a. Arcing faults.
   b. Simultaneous faults.
   c. Explicit negative sequence.
   d. Mutual coupling in zero sequence.

2.02 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:
   1. Protective device designations and ampere ratings.
   2. Cable size and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study:
   1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
      a. Voltage.
      b. Calculated fault-current magnitude and angle.
      c. Fault-point X/R ratio.
      d. Equivalent impedance.
2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
   a. Voltage.
   b. Calculated symmetrical fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. Calculated asymmetrical fault currents:
      1) Based on fault-point X/R ratio.
      2) Based on calculated symmetrical value multiplied by 1.6.
      3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
   a. Voltage.
   b. Calculated symmetrical fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. No AC Decrement (NACD) ratio.
   e. Equivalent impedance.
   f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
   g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

F. Protective Device Coordination Study:
   1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
      a. Phase and Ground Relays:
         1) Device tag.
         2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
         3) Recommendations on improved relaying systems, if applicable.
      b. Circuit Breakers:
         1) Adjustable pickups and time delays (long time, short time, ground).
         2) Adjustable time-current characteristic.
         3) Adjustable instantaneous pickup.
         4) Recommendations on improved trip systems, if applicable.
      c. Fuses: Show current rating, voltage, and class.

G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices.
Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
   a. Power utility's overcurrent protective device.
   b. Medium-voltage equipment overcurrent relays.
   c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
   d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
   e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
   f. Cables and conductors damage curves.
   g. Ground-fault protective devices.
   h. Motor-starting characteristics and motor damage points.
   i. Generator short-circuit decrement curve and generator damage point.
   j. The largest feeder circuit breaker in each motor-control center and panelboard.

5. Series rating on equipment allows the application of two series interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Both devices share in the interruption of the fault and selectivity is sacrificed at high fault levels. Maintain selectivity for tripping currents caused by overloads.

6. Provide adequate time margins between device characteristics such that selective operation is achieved.

7. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.
3.02 PROTECTIVE DEVICE COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:
   1. To normal system low-voltage load buses where fault current is 10 kA or less.
   2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Transformer Primary Overcurrent Protective Devices:
   1. Device shall not operate in response to the following:
      a. Inrush current when first energized.
      b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
      c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
   2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

H. Motor Protection:
   1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
   2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.
K. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Switchgear.
3. Low-voltage switchgear.
4. Standby generators and automatic transfer switches.
5. Branch circuit panelboards.

M. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.

3.03 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:

1. Determine load-flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
2. Determine load-flow and voltage drop based on 80 percent of the design capacity of the load buses.
3. Prepare the load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.04 MOTOR-STARTING STUDY

A. Perform a motor-starting study to analyze the transient effect of the system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of the motor starting on the power system stability.

B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and voltage sags so as not to affect the operation of other utilization equipment on the system supplying the motor.
3.05 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 241 and IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other 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. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
8. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
9. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
10. Maximum demands from service meters.
11. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
12. Motor horsepower and NEMA MG 1 code letter designation.
13. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
14. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
   a. Special load considerations, including starting inrush currents and frequent starting and stopping.
   b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
3.06 FIELD ADJUSTING

A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.07 DEMONSTRATION

A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:

1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.
2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
3. Adjust, operate, and maintain overcurrent protective device settings.
END OF SECTION 260573
PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.03 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.04 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.
   1. Arc-flash study input data, including completed computer program input data sheets.
   2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.
      a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.
1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Arc-Flash Study Specialist.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.06 CLOSEOUT SUBMITTALS

A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

B. Operation and Maintenance Procedures: In addition to items specified in Section 017823 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.07 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 unacceptable.

B. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.01 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers: Subject to compliance with requirements, provide software by one of the following:
   1. ESA Inc.
   2. Operation Technology, Inc.
   3. Power Analytics, Corporation.
   4. SKM Systems Analysis, Inc.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.02 SHORT-CIRCUIT STUDY REPORT CONTENT

A. Executive summary.
B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:
   1. Protective device designations and ampere ratings.
   2. Cable size and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output:
   1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
      a. Voltage.
      b. Calculated symmetrical fault-current magnitude and angle.
      c. Fault-point X/R ratio.
      d. No AC Decrement (NACD) ratio.
      e. Equivalent impedance.
      f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
      g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

F. Incident Energy and Flash Protection Boundary Calculations:
   1. Arcing fault magnitude.
   2. Protective device clearing time.
   3. Duration of arc.
   5. Working distance.
   6. Incident energy.

G. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.03 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch (76-by-127-mm) thermal transfer label of high-adhesion polyester for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
   1. Location designation.
   2. Nominal voltage.
   3. Flash protection boundary.
PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.02 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:
   1. To normal system low-voltage load buses where fault current is 10 kA or less.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:
   1. Electric utility's supply termination point.
   2. Switchgear.
   3. Low-voltage switchgear.
   4. Standby generators and automatic transfer switches.
   5. Branch circuit panelboards.

3.03 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.
B. Use the short-circuit study output and the field-verified settings of the overcurrent devices.

C. Calculate maximum and minimum contributions of fault-current size.
   1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
   2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except 240-V ac and 208-V ac systems fed from transformers less than 125 kVA.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
   1. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
   1. When the circuit breaker is in a separate enclosure.
   2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.04 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.
   1. Verify completeness of data supplied on the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
   2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
   3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.

B. Gather and tabulate the following input data to support coordination study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative.
who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other 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. Obtain electrical power utility impedance at the service.

3. Power sources and ties.

4. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.

5. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.

6. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.

7. Motor horsepower and NEMA MG 1 code letter designation.

8. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

9. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

3.05 LABELING

A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:

1. Motor-control center.
2. Low-voltage switchboard.
3. Switchgear.
4. Medium-voltage switch.
5. Control panel.

3.06 APPLICATION OF WARNING LABELS

A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.07 DEMONSTRATION

A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION 260574
PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.
   3. Electronic-grade panelboards.

1.03 DEFINITIONS

A. SVR: Suppressed voltage rating.


1.04 ACTION SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, SPD, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
   2. Detail enclosure types and details for types other than NEMA 250, Type 1.
   3. Detail bus configuration, current, and voltage ratings.
   4. Short-circuit current rating of panelboards and overcurrent protective devices.
   5. Include evidence of NRTL listing for series rating of installed devices.
   6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   7. Include wiring diagrams for power, signal, and control wiring.
   8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.
B. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Quality-Control Reports:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys: Two spares for each type of panelboard cabinet lock.
   2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.
   3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.08 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 1.

F. Comply with NFPA 70.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.10 PROJECT CONDITIONS

A. Environmental Limitations:
   1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Not exceeding [minus 22 deg F (minus 30 deg C)] [23 deg F (minus 5 deg C)] to plus 104 deg F (plus 40 deg C).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet (2000 m).

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Construction Manager no fewer than two days in advance of proposed interruption of electric service.
   2. Do not proceed with interruption of electric service without Construction Manager's written permission.
   3. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces.
Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.12 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Enclosures: Flush- and surface-mounted cabinets.
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
      c. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
   2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
   3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
   4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
   5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
   6. Finishes:
      a. Panels and Trim: galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
      c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

C. Incoming Mains Location: Top.

D. Phase, Neutral, and Ground Buses:
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

E. Conductor Connectors: Suitable for use with conductor material and sizes.
   2. Main and Neutral Lugs: Mechanical type.
   3. Ground Lugs and Bus-Configured Terminators: Mechanical type.

F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

H. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include size and type of allowable upstream and branch devices, listed and labeled for series-connected short-circuit rating by an NRTL.


2.02 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.03 DISTRIBUTION PANELBOARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings of Easton Electrical Inc.; Cutler-Hammer Business Unit or comparable product by one of the following:
   1. Siemens Energy & Automation, Inc.
   2. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
   1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.

D. Mains: CB.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.04 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings by Eaton Electrical Inc.; Cutler-Hammer Business Unit or comparable product by one of the following:
   2. Siemens Energy & Automation, Inc.
   3. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Trim hinges to box; secured with flush latch with tumbler lock; keyed alike.

F. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.05 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   4. Square D; a brand of Schneider Electric.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
   3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
   4. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
      a. Standard frame sizes, trip ratings, and number of poles.
      b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
      c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
d. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.

e. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

f. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
   1. Fuses, and Spare-Fuse Cabinet: Comply with requirements specified in Section 262813 "Fuses."
   2. Fused Switch Features and Accessories: Standard ampere ratings and number of poles.
   3. Auxiliary Contacts: [One] [Two] normally open and normally closed contact(s) that operate with switch handle operation.

2.06 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.02 INSTALLATION

A. Install panelboards and accessories according to NECA 407.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.
E. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

F. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit-breaker trip ranges.

G. Install filler plates in unused spaces.

H. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.

I. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

J. Comply with NECA 1.

3.03 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.04 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.
E. Tests and Inspections:
1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:
   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
   b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
   c. Instruments and Equipment:
      1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

F. Panelboards will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as indicated.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
   1. Measure as directed during period of normal system loading.
   2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
   3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
   4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.06 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. This Section is to coordinate with and be complementary to the General Conditions and
      Supplementary General Conditions of the work, and Division 01 Specification Sections
      wherever applicable to Mechanical and Electrical Work.
   B. Section 01 31 46 – Special Requirements for Mechanical and Electrical Work shall apply.
   C. Section 26 05 00 – General Provisions For Electrical Work shall apply

1.2 SUMMARY
   A. Section Includes:
      1. Hospital-grade receptacles, 125 V, 20 A.
         a. GFCI receptacles, 125 V, 20 A.
      2. Toggle switches, 120/277 V, 20 A.
      3. Occupancy sensors.
      4. Wall plates.

1.3 DEFINITIONS
   A. GFCI: Ground-fault circuit interrupter.
   B. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of product.
   B. Shop Drawings: List of legends and description of materials and process used for premarking
      wall plates.
   C. Samples: One for each type of device and wall plate specified, in each color specified.

1.5 INFORMATIONAL SUBMITTALS
   A. Field quality-control reports.
1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. RoHS compliant.

C. Comply with NEMA WD 1.

D. Comply with New York City Electrical Code (NYCEC).

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in, NYCEC Article 100 by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Devices for Owner-Furnished Equipment:
   1. Receptacles: Match plug configurations.

G. Device Color:
   1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 NYCEC or device listing.
   2. Wiring Devices Connected to Essential Electrical System: Red.

H. Wall Plate Color: For plastic covers, match device color.

I. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 HOSPITAL-GRADE RECEPTACLES, 125 V, 20 A

A. Hospital-Grade, Single Receptacles, 125 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated
      b. Leviton Manufacturing Co.
      c. Arrow Hart
      d. Pass & Seymour
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498 Supplement sd and FS W-C-596.

B. Hospital-Grade, Duplex Receptacles, 125 V, 20 A:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated
   b. Leviton Manufacturing Co.
   c. Arrow Hart
   d. Pass & Seymour
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498 Supplement sd and FS W-C-596.

C. Hospital-Grade, Duplex GFCI Receptacles, 125 V, 20 A:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated
   b. Leviton Manufacturing Co.
   c. Arrow Hart
   d. Pass & Seymour
2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Single-piece, rivetless, nickel-plated, all-brass grounding system.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Type: Non-feed through.
5. Standards: Comply with UL 498 supplement sd, UL 943 Class A, and FS W-C-596.
6. Marking: Listed and labeled as complying with [NFPA 70] [NYCEC], "Health Care Facilities" Article.

2.3 TOGGLE SWITCHES, 120/277 V, 20 A

A. Single-Pole Switches, 120/277 V, 20 A:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated
   b. Leviton Manufacturing Co.
   c. Arrow Hart
   d. Pass & Seymour
2. Standards: Comply with UL 20 and FS W-S-896.

B. Lighted Single-Pole Switches, 120/277 V, 20 A:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated
   b. Leviton Manufacturing Co.
   c. Arrow Hart
   d. Pass & Seymour

2. Description: Handle illuminated when switch is off.

3. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

2.4 OCCUPANCY SENSORS

A. Wall Switch Sensor Light Switch, Dual Technology:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated
      b. Leviton Manufacturing Co.
      c. Arrow Hart
      d. Pass & Seymour
   2. Description: Switchbox-mounted, combination lighting-control sensor and conventional switch lighting-control unit using dual (ultrasonic and passive infrared) technology.
   4. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
   5. Adjustable time delay of five, 10, 15, 20, minutes.
   6. Able to be locked to Manual-On mode.
   7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux).
   8. Connections: Provisions for connection to BAS.

2.5 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.

   1. Plate-Securing Screws: Metal with head color to match plate finish.
   2. Material for Finished Spaces: Smooth, high-impact thermoplastic
   4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated on drawings.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall comply with NYCEC, Article 300, without pigtails.
4. Existing Conductors:
   a. Cut back and pigtail, or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtail for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
   1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.
   2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. 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.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPCTACLES
   A. Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION
   A. Comply with Section 260553 "Identification for Electrical Systems."
   B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL
   A. Test Instruments: Use instruments that comply with UL 1436.
   B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
   C. Tests for Receptacles:
      1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

D. Wiring device will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 26 27 26
PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
1. Cartridge fuses rated 600-V ac and less for use in control circuits enclosed switches enclosed controllers.
2. Plug fuses rated 125-V ac and less for use in plug-fuse-type enclosed switches fuseholders.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include the following for each fuse type indicated:
1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
   a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
   b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit on translucent log-log graph paper.
4. Coordination charts and tables and related data.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

1.06 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Comply with UL 248-11 for plug fuses.

1.07 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.08 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Bussmann, Inc.
   2. Edison Fuse, Inc.
   3. Ferraz Shawmut, Inc.
   4. Littelfuse, Inc.

2.02 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.02 FUSE APPLICATIONS

A. Cartridge Fuses:
   1. Service Entrance: Class L, fast acting.
   2. Motor Branch Circuits: Class RK5, time delay.

3.03 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install plug-fuse adapters in Edison-base fuseholders and sockets. Ensure that adapters are irremovable once installed.

C. Install spare-fuse cabinet(s).

3.04 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813
PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Fusible switches.
   2. Nonfusible switches.
   3. Receptacle switches.
   4. Molded-case circuit breakers (MCCBs).
   5. Molded-case switches.

1.03 DEFINITIONS

A. NC: Normally closed.
B. NO: Normally open.
C. SPDT: Single pole, double throw.

1.04 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.05 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
   1. Enclosure types and details for types other than NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current ratings (interrupting and withstand, as appropriate).
   4. Include evidence of NRTL listing for series rating of installed devices.
   5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Submit on translucent log-log graph paper.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
   1. Wiring Diagrams: For power, signal, and control wiring.

1.06 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Manufacturer's field service report.

1.07 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
   2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Submit on translucent log-log graph paper.

1.08 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   2. Fuse Pullers: Two for each size and type.
1.09 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NFPA 70.

1.10 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).

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of electric service.
   2. Indicate method of providing temporary electric service.
   3. Do not proceed with interruption of electric service without Construction Manager's written permission.
   4. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
PART 2 - PRODUCTS

2.01 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   4. Square D; a brand of Schneider Electric.

B. Type GD, General Duty, Single Throw, 240-V ac, 800 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with cartridge fuse interiors to accommodate indicated fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
   3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
   4. Lugs: Mechanical type, suitable for number, size, and conductor material.
   5. Service-Rated Switches: Labeled for use as service equipment.

2.02 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   4. Square D; a brand of Schneider Electric.

B. Type GD, General Duty, Single Throw, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   2. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.03 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.


D. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

E. Features and Accessories:
   1. Standard frame sizes, trip ratings, and number of poles.
   2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
   3. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.

2.04 MOLDED-CASE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   4. Square D; a brand of Schneider Electric.

B. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Features and Accessories:
   1. Standard frame sizes and number of poles.
   2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
   3. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
   4. Alarm Switch: One NO contact that operates only when switch has tripped.

2.05 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
   1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
   2. Outdoor Locations: NEMA 250, Type 3R.
   3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
   4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.02 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.03 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.04 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Acceptance Testing Preparation:
   1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

D. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   3. Perform the following infrared scan tests and inspections and prepare reports:
a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.

c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

END OF SECTION 262816
PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. This Section is to coordinate with and be complementary to the General Conditions and Supplementary General Conditions of the Work, wherever applicable to Mechanical and Electrical Work.

B. Section 01 31 46 - Special Requirements for Mechanical and Electrical Work shall apply.

C. Section 26 05 12 - General Provisions for Electrical Work shall apply.

1.02 DESCRIPTION OF WORK

A. The work includes the furnishing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all lighting fixtures in accordance with Drawings and Specifications.

1.03 QUALITY ASSURANCE

A. Manufacturers - Firms regularly engaged in manufacturer of lighting fixtures whose products have been in satisfactory use in similar service for not less than 5 years.

B. Lighting fixtures shall be listed and labeled by Underwriters Laboratories, Inc. and shall comply with standards of NEMA, ANSI, OSHA, and National Electrical Code (NFPA 70) for construction and installation.

C. Provide lighting fixtures whose performance under specified conditions is certified by the manufacturer.

D. Provide lighting fixtures, drivers and lamps produced by a manufacturer listed as an Approved Manufacturers in this Section, or as scheduled on the Drawings.

E. Alternate or substitute manufacturers may be included with the bid with separate adds or deducts from the base bid for each fixture type, subject to approval by the Architect. Substitute manufacturers must be identified by name and may not be changed by the bidder after the bids are submitted.

F. Special designs and/or unique applications of standard units may require samples and mock-ups and other developmental work which, is to be specifically provided for in the Contractors bid.

1.04 SUBMITTALS

A. Refer to Section 01 36 46 - Special Requirements for Mechanical and Electrical Work, and submit shop drawings. Shop drawings for each lighting fixture type shall include:
1. Details of construction and finishes.
2. Drawings to scale.
3. Catalog cuts (without required details not acceptable).
4. Electrical ratings, mounting, drivers, lenses, and emitters.
5. Certified photometric data, where noted.
7. Installation instruction where required.

1.05 SAMPLES

A. Submit for review, samples requested by the Architect when and where directed, or as specified hereinafter. The fixtures or components are to be tagged with the project name and fixture type. Samples shall be held by the Contractor available for reference throughout the construction period. Fixtures or components under the Contract shall be identical with the approved samples. No approved reference sample (fixture or component) is to be installed on the Project.

1.06 GUARANTEE

A. Refer to Section 01 36 46 - Special Requirements for Mechanical and Electrical Work.

PART 2 - PRODUCTS

2.01 APPROVED MANUFACTURERS

A. Lighting Fixtures
   1. For lighting fixtures
      a. As indicated in Lighting Fixture Schedule on Drawings.

2.02 LIGHTING FIXTURES - GENERAL

A. Furnish, install and connect interior and exterior lighting fixtures as scheduled on the Drawings, and as required for a complete and satisfactory operating system.

B. Actual location of fixtures shall be as shown on the architectural reflected ceiling plans, or as directed by the Architect. Spaces for fixture insertion will be provided under the Section that covers the ceiling installation. Plaster and other frames shall be turned over to the Section for General Construction for setting and installation. Contractor shall be responsible for obtaining the latest architectural plans, and field verification. The Contractor's attention is directed to the requirements of the acoustical ceiling, particularly to the need for close coordination between the ceiling construction details and lighting fixture design. The Electrical Contractor shall be responsible for coordinating mounting hardware to match ceiling type.

C. Lighting fixture catalog numbers shall be considered only as a guide. All fixtures must incorporate the general and particular requirements included in the Contract Documents. It may be necessary to modify the manufacturer's standard fixture corresponding to the designated type or catalog number.
D. All methods of construction and details of workmanship, where not specifically described or shown on the Drawings, shall be satisfactory to the Architect and shall be subject to his approval.

2.03 LIGHTING FIXTURES - FABRICATION

A. Provide required thickness of metal, plastic and composite materials so that all fixtures are rigid, stable, and will resist deflection, twisting, warping under normal installation, and relamping procedures.
   1. All luminaire housings minimum (20) (22) gauge cold rolled steel, unless a heavier gauge is specified or required by NEC or Local Codes.
   2. All aluminum extrusion housing minimum 3/16" thick.
   3. All acrylic & polycarbonate lenses and/or diffusers minimum \(\frac{1}{8}\)" thick.

B. Provide positive, durable, means of connection at all joints as required. No hollow rivets, unless specifically approved, are acceptable.

C. Provide neoprene, silicone, rubber, or other appropriate gasketing, stops, and barriers where required to prevent light leak, control sound and vibration, prevent water leaks and, if pertinent, water vapor penetration.

D. Provide finished product with the following minimum qualities:
   1. Ground and/or burr free metal edges.
   2. Tight fitting connections, hinges and closures.
   3. Clean neat corners, edges, trims and frames.

E. All cast parts, including die-cast members, shall be of uniform quality; free from blow holes, pores, hard spots, shrinkage defects, cracks or other imperfections that affect strength and appearance, or are indicative of inferior metals or alloys.

2.04 FINISHES

A. Fixture finishes shall be applied in a manner that will assure a durable wear resistant surface.
   1. Prior to finishing, all surfaces must be free from foreign materials such as dirt, rust, oil, polishing compounds and mold release agents.
   2. Where necessary surface cleaned by accepted chemical means shall receive corrosion inhibiting (phosphating) treatment assuring positive paint adhesion.
   3. All castings and extrusions machined, sanded or similarly treated, and given minimum one coat of baked-on clear methacrylate lacquer, unless a painted finish is specified.
   4. Aluminum surfaces exposed to weather (other than anodized reflectors covered elsewhere) shall receive a duronodic or polyester powder paint finish as specified for corrosion resistance.
   5. Sheet steel fixture housings, iron and steel parts, which have not received phosphating treatment ("Bonderizing" or similar process) or are to be utilized in exterior applications, shall be made corrosion resistant by zinc or cadmium plating or hot-dip galvanizing.
   6. All exterior (visible) finishes must be approved by the Architect.

2.05 FIXTURE TRIMS

A. Fixtures shall have finish trim designed as specified in the Lighting Fixture Specifications.
B. Provide trim details as shown on the Drawings or as specified. The trim finish and dimensions are subject to the approval by the Architect.
   1. Mitered corners shall be smoothed before shop finish is applied. No lapping of trim metal for all flush mounted ceiling trims for rectangular or square recessed fixtures.
   2. All exposed ceiling trim and inside reveals on all fixtures shall be painted in a color to match the Architect's sample.

2.06 LED LIGHT FIXTURES

A. General:
   1. LED light fixtures shall be in accordance with IES, NFPA, UL, as shown on the drawings, and as specified.
   2. LED light fixtures shall be Reduction of Hazardous Substances (RoHS)-compliant.
   3. LED drivers shall include the following features unless otherwise indicated:
      a. Minimum efficiency: 85% at full load.
      b. Minimum Operating Ambient Temperature: -20°C. (-4°F.)
      c. Input Voltage: 120- 277V (±10%) at 60Hz.
      d. Integral short circuit, open circuit, and overload protection.
      e. Power Factor ≥0.95.
      f. Total Harmonic Distortion ≤20%.
   4. LED modules shall include the following features unless otherwise indicated:
      a. Comply with IES LM-79 and LM-80 requirements.
      b. Minimum CRI 80 and color temperature 3000° K unless otherwise specified in LIGHTING FIXTURE SCHEDULE.
      c. Minimum Rated Life: 50,000 hours per IES L70.
      d. Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.

B. LED Downlights:
   1. Housing, LED driver, and LED module shall be products of the same manufacturer.

C. LED Troffers:
   1. LED drivers, modules, and reflector shall be accessible, serviceable, and replaceable from below the ceiling.
   2. Housing, LED driver, and LED module shall be products of the same manufacturer.

2.07 WIRING

A. All wiring shall comply with the following standards:
   1. All wiring within lighting fixtures, or from the connection to the building wiring system, shall be as specified under Section 26 05 19, "WIRE AND CABLE".
   2. Wiring within fixture housing is to be concealed, except where the fixture design or mounting dictates otherwise.
   3. Wiring channels and wireways shall be free from projections and rough or sharp edges throughout, and at points or edges over which conductors must pass and may be subject to injury or wear.
   4. Insulated bushings shall be installed at points of entrance and exit of flexible wiring.
   5. All joints between fixture wiring shall be made with Buchanan #2008S or Thomas and Betts solderless connectors.
PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide and install all lighting equipment described in the Contract Documents and/or as modified by approved shop drawings. Installation shall be carried out in accordance with N.Y.C. Electrical Code requirements, manufacturer's instructions, and with recognized industry practices. Comply with NEMA standards and with applicable portions of NEMCA's "Standard of Installation".

1. Verify fixture locations with architectural plans, reflected ceiling plans and other references prior to installation.
2. Check for adequate headroom and non-interference with other equipment, such as ducts, pipes, openings, etc.
3. In Mechanical Equipment Rooms modify locations and mounting to suit conditions as directed.
4. Install rows of fixtures in straight lines, except as noted. Install fixtures so that fixture access is from same side.
5. Except for lighting fixtures connected to emergency power circuits, provide disconnect means for each lighting fixture do disconnect simultaneously from the source of supply all conductors of the ballast, including grounding conductor, if any.
6. Notify Architect in writing of conditions detrimental to proper and timely completion of the work.

B. The housing of recessed lighting fixtures shall be adequately protected during installation.

1. Provide internal blocking or framing to provide perfect linear alignment and to prevent distortion of sides or dislocation of matching parts.

3.02 SUPPORTS

A. Provide mounting frames (plaster frames for example) to other trades as required for installation and as called for under other sections of these Contract Documents. Frames are to be finished matte white baked enamel, unless otherwise noted.

B. Provide bars, angles or other attachment devices for all recessed fixtures. Fixtures shall be securely attached so there is minimum possible movement up, down, or sideways. Fixtures shall be mounted to permit access of wiring. Fastening devices shall be of a positive, locking type, and will not require the use of special tools to apply or remove. Tie shall not be used in place of fastening devices.

C. Additional running bars, shall be furnished by the Contractor for support of recessed fixtures and shall be utilized by the Contractor for that support. Where additional running bars can be furnished, the Contractor shall support weight of the fixture from the main running bars (black iron) or from the structural steel, or concrete, by means of inserts, handing rods, Kindorf or Unistrut channels.

D. Surface mounted or pendant fixtures mounted on suspended ceilings shall be supported by approved running straps, bars or channels from the top of the ceiling outlet box to the black iron where it exists or to the structural steel or concrete. Surface mounted or pendant fixtures installed on an existing suspended ceiling shall be supported in conformance with existing conditions or as shown on the Drawings.
E. Where necessary to meet Code requirements, enclosure housing shall be constructed to provide a one-hour fire rating.

F. Contractor shall be responsible only for the necessary adjustments in ceiling required to install lighting fixtures. Contractor shall verify all ceiling conditions from the Architectural plans and furnish appropriate mounting details for each lighting fixture.

G. Provide pendant or surface mounted fixtures with required mounting devices and accessories. Coordinate locations of fixtures in mechanical areas, and if required, modify locations and mounting to suit conditions as directed. Provide mounting stems on pendant fixtures of the correct length to uniformly maintain the fixture heights shown on the Drawings, or established in the field.

3.03 ADJUSTMENT

A. After the installation of lighting fixtures is completed, fixtures so requiring (both interior and exterior units) shall be adjusted after dark under supervision of the Architect and/or Owner.

3.04 CLEANING

A. Lighting fixture mounting frames, plaster rings, etc. are required to be installed prior to the finishing assembly which shall not be installed until the project is "broom clean". When the fixture location or construction cannot permit sequential installation, the Contractor shall carefully protect all reflectors, lenses, flanges, and other visible surfaces.

B. Before final acceptance by the Architect, all protective (strippable) coatings, dust, finger marks, paint spots and any other materials deleterious to the appearance or functioning of the lighting fixtures must be removed. Abrasive cleaners are not permitted.

3.05 INSPECTION

A. Contractor shall examine location where the lighting fixtures are to be installed, determine space conditions and notify Architect/Engineer in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

C. Upon completion of the installation, lighting equipment must be in first class operating order and free from defects in condition and finish.
   1. Fixtures shall be completely clean and free from finger marks, dust, plaster or paint spots.
   2. Any reflectors, lenses, diffusers, side panels or other parts damaged prior to the final inspection shall be replaced at no expense to the Owner.
   3. Housings shall be rigidly installed and adjusted to a neat flush fit with the ceiling.
   4. No light leaks shall be permitted at the ceiling line or from any visible part or joints.
3.06 FIELD QUALITY CONTROL

A. Upon completion of installation of lighting fixtures, and after energization, test system to demonstrate compliance with the contract requirements. When possible, correct malfunctioning units at the site and retest. Otherwise, remove and replace with new units.

END OF SECTION 26 51 13
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. This Section is to coordinate with and be complementary to the General Conditions and Supplementary General Conditions of the work, and Division 01 Specification Sections wherever applicable to Mechanical and Electrical Work.
   B. Section 01 31 46 – Special Requirements for Mechanical and Electrical Work shall apply.
   C. Section 26 05 00 – General Provisions For Electrical Work shall apply.

1.2 SUMMARY
   A. Section includes the following types of LED luminaires:
      1. Downlight.
      2. Lay-in recessed.
      3. Exit Lights.

1.3 DEFINITIONS
   A. CCT: Correlated color temperature.
   B. CRI: Color Rendering Index.
   C. Fixture: See "Luminaire."
   D. IP: International Protection or Ingress Protection Rating.
   E. LED: Light-emitting diode.
   F. Lumen: Measured output of lamp and luminaire, or both.
   G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of product.
      1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IES "Lighting Measurements Testing and Calculation Guides" for each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.
   a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.
   1. Include plans, elevations, sections, and mounting and attachment details.
   2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Luminaires.
   2. Suspended ceiling components.
   3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches (300 mm) of the plane of the luminaires.
   4. Structural members to which equipment and luminaires will be attached.
   5. Initial access modules for acoustical tile, including size and locations.
   6. Items penetrating finished ceiling, including the following:
      a. Other luminaires.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
   7. Moldings.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of luminaire.
E. Product Test Reports: For each type of luminaire, for tests performed by a qualified testing agency.
F. Sample warranty.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS
A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps or Luminaires with integral lamps: 10% of each type and rating installed. Furnish at least one of each type.
2. Diffusers and Lenses: 2% of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE
A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.
B. Provide luminaires from a single manufacturer for each luminaire type.
C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.
1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

B. Ambient Temperature: [41 to 104 deg F (5 to 40 deg C)] [5 to 104 deg F (Minus 15 to plus 40 deg C)].

C. Altitude: Sea level to 1000 feet (300 m).

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, (NYCEC) by a qualified testing agency, and marked for intended location and application.

B. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

   a. "USE ONLY" and include specific lamp type.
   b. Lamp diameter, shape, size, wattage, and coating.
   c. CCT and CRI.

C. Recessed luminaires shall comply with NEMA LE 4.
2.3 MATERIALS

A. Metal Parts:
   1. Free of burrs and sharp corners and edges.
   2. Sheet metal components shall be steel unless otherwise indicated.
   3. Form and support to prevent warping and sagging.

B. Steel:
   1. ASTM A 36/A 36M for carbon structural steel.
   2. ASTM A 568/A 568M for sheet steel.

C. Stainless Steel:
   1. Manufacturer's standard grade.
   2. Manufacturer's standard type, ASTM A 240/240 M.

D. Galvanized Steel: ASTM A 653/A 653M.

E. Aluminum: ASTM B 209.

2.4 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.5 LUMINAIRE SUPPORT

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage

D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

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

3.2 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:
   1. Sized and rated for luminaire weight.
   2. Able to maintain luminaire position after cleaning and relamping.
   3. Provide support for luminaire without causing deflection of ceiling or wall.
   4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaires:
   1. Secured to outlet box.
   2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
   3. Trim ring flush with finished surface.

F. Ceiling-Grid-Mounted Luminaires:
   1. Secure to any required outlet box.
   2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.

G. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation as reflected on the drawings and elsewhere in these specifications.

2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal. Verify that dimmed fixtures return to full-on state at loss of power.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Occupancy Adjustments: Within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.

2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3. Adjust the aim of luminaires in the presence of the Architect and/or Engineer.

END OF SECTION 26 51 19