

Project Number: 19002

Bid Documents

Volume 2 of 2

January 06, 2022

Maurice J. McDonough High School

Addition / Renovation

PSC #08.009.19 LP

7165 Marshall Corner Road
Pomfret, MD 20675

Charles County Public Schools



MAURICE J. MCDONOUGH HIGH SCHOOL
ADDITION / RENOVATION

PROJECT DIRECTORY

Maurice J. McDonough High School Addition / Renovation
7165 Marshall Corner Road, Pomfret, Maryland 20675

CHARLES COUNTY PUBLIC SCHOOLS

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McDonough High School ACM report dated July, 2005

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SECTION 210110 - FIRE PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, general provisions of Contract, as well as Division-22 and Division-26 sections shall apply to this Section.

1.2 SUMMARY

- A. This Section specifies automatic sprinkler and standpipe systems for buildings and structures. Materials and equipment specified in this Section include:
 - 1. Pipe, fittings, valves, and specialties;
 - 2. Sprinklers, fire department valve cabinets, and accessories.
- B. Products furnished but not installed include sprinkler head cabinet with spare sprinkler heads. Furnish to the Owner's maintenance personnel.

1.3 DEFINITIONS

- A. Pipe sizes used in this Specification are Nominal Pipe Size (NPS).
- B. Other definitions for fire protection systems are listed in the most current edition of NFPA Standards 13 and 14.
- C. Working Plans as used in this Section means those documents (including drawings and calculations) prepared pursuant to the requirements contained in the most current edition of NFPA 13 for obtaining approval of the authority having jurisdiction.

1.4 SYSTEM DESCRIPTION

- A. The scope of this project includes system replacement (i.e. new piping, sprinkler heads, accessories, etc) in all renovated areas as well as the extension of the system into the new addition.
- B. Existing system shall remain in service until new system shall be installed and approved. Interruptions of service for the purposes of making final connections to existing piping shall be coordinated in advance with owner and local authority having jurisdiction.
- C. The sprinkler system is served by pressurized underground storage tanks located below grade adjacent (and extending into) the mechanical room. The contractor shall perform a flow test to determine the flow and pressure available to assist in the design / sizing of the system.

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1.5 SUBMITTALS

- A. Product Data: Include each type sprinkler head, valve, piping specialty, fire protection specialty, fire department connection, fire and jockey pumps and fire department valve cabinet specified.
- B. Shop Drawings: Submit drawings which have been prepared in accordance with the most current editions of NFPA, UL, FM, as well as the owner's insurance carrier requirements. Shop drawings shall include hydraulic calculations where applicable, and which have been approved by the authority having jurisdiction.
 - 1. Sprinkler shop drawings shall be integrated into the Contractor's installation/coordination drawings.
 - 2. Shop drawings shall include a written statement indicating compliance with all applicable requirements of NFPA, UL, FM, and the Owner's insurance carrier.
- C. Coordination Drawings: Detail fire protection piping systems in accordance with Division-22 Section "Basic Plumbing Requirements." Fire protection piping shall be coordinated with work of all other trades.
- D. Maintenance Data: For each type sprinkler head, valve, piping specialty, fire protection specialty, fire department connection, fire and jockey pump, and fire department valve cabinet specified, include in operating and maintenance manual.
- E. Quality Control Submittals:
 - 1. Welders' qualification certificates. Submit for each qualified welder the following documentation according to AWS B2.1. Welding Procedure Specification (WPS), Procedure Qualification Record (PQR), Welder Qualification Record (WQR), verifying the AWS qualification within the previous six (6) months, or certified work history showing no break in work.
 - 2. Test Reports and Certificates: Include "Contractor's Material & Test Certificate for Aboveground Piping" and "Contractor's Material & Test Certificate for Underground Piping" as described in the most current edition of NFPA 13.
 - 3. Internal Inspection of Piping; where sprinkler piping is welded, an obstruction investigation will be conducted and report submitted.
- F. Computer (CADD) files of drawings will not be made available to the Contractor for any purposes.

1.6 MATERIAL, EQUIPMENT AND SUBSTITUTION REQUIREMENTS

- A. Use products of one manufacturer where two or more items of same kind of equipment are required.

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- B. Materials and equipment shall have a record of two (2) years successful field use.
- C. Where a specific manufacturer is listed on the drawings, that manufacturer shall be considered the basis of design for that particular item of equipment. Only the basis of design manufacturer has been verified to meet the project requirements (i.e. dimensions, weights, service clearances, electrical requirements, etc.).
- D. Where the drawings and/or specifications indicate more than one manufacturer for a particular item of equipment, only those listed may submit products and services to be included in the work; manufacturers other than those listed will not be acceptable. Should the contractor choose to use one of the specified manufacturers other than the basis of design, it shall be the responsibility of the contractor to verify that the equipment meets all project requirements including, but not limited to, verification of all dimensions, weights, service clearances, electrical requirements, etc. All changes incurred shall be the responsibility of the contractor and shall be provided at no additional cost to the owner.
- E. Substitutions must be submitted for consideration seven (7) days prior to the original bid date. Consideration of substitutions shall be at the sole discretion of the Engineer. Substitution submittals shall include all information required in the "Submittals" paragraph of this specification section, as well as all other requirements indicated through the Division-23 specifications. Substitutions will not mitigate, in any way, the Contractor's responsibility in complying with the coordination, contract requirements or design intent. Any additional electrical, structural or special requirements, etc. shall be the responsibility of the Contractor. Also, any additional cost incurred as a result of substitution shall be the responsibility of the Contractor.
- F. Nameplate: For each piece of power operated mechanical equipment provide a permanent operational data nameplate indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.
- G. Where items of equipment are indicated as Base Bid on the bid form include in the Bid price the cost of providing the equipment upon which the specification is based. In addition, submit with bid for Owner's consideration the amount to be added or deducted from the base bid for other listed manufacturers' equipment. Owner will advise Contractor within forty-five (45) days after award of contract of his selection.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Installation and alterations of fire protection piping, equipment, specialties, and accessories, and repair and servicing of equipment shall be performed only by a qualified installer having a minimum of five (5) years' experience with work similar in size and scope to this project.
- B. Qualifications for Welding Processes and Operators: Comply with the requirements of AWS B2.1", Specifications for Qualifications of Welding Procedures and Welders for Piping and Tubing, Level AR-3."
- C. Regulatory Requirements: Comply with the requirements of the most current edition of

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the following codes:

1. NFPA 13 - Standard for the Installation of Sprinkler Systems.
2. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems.
3. UL and FM Compliance: Fire protection system materials and components shall be Underwriter's Laboratories listed and labeled, and Factory Mutual approved for the application anticipated.
4. In addition to all regulatory requirements, the complete fire protection system shall meet the requirements of the Owner's insurance carrier.

D. Miscellaneous Materials:

1. Sprinkler Wrenches: Furnish to Owner, two (2) wrenches for each type of sprinkler head installed as provided by the sprinkler manufacturer.
2. Sprinkler Heads and Cabinets: Furnish six extra sprinkler heads of each style included in the project. Furnish each style with its own sprinkler head cabinet and special wrenches as specified in this Section.

E. Structural Certification:

1. The Sprinkler Contractor shall provide certification from a Maryland Registered Engineer that the existing building structure is capable of supporting all proposed sprinkler system piping. The certification letter must be signed and sealed prior to the submission of shop drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering fire protection system products which may be incorporated in the work include the following:

1. Gate Valves:
 - a. Fairbanks
 - b. Jenkins
 - c. Kennedy Valve, Div of ITT Grinnell Valve Co., Inc.
 - d. Stockham
2. Swing Check Valves:
 - a. Fairbanks

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- b. Jenkins
 - c. Kennedy Valve, Div of ITT Grinnell Valve Co., Inc.
 - d. Star Sprinkler Corp.
 - e. Stockham
 - f. Victaulic
3. Water Flow Indicators:
- a. Reliable Automatic Sprinkler Co., Inc.
 - b. Star Sprinkler Corp.
 - c. Viking Corp.
4. Fire Department Valve:
- a. Guardian Fire Equipment, Inc.
 - b. Elkhart Brass
5. Sprinkler Heads:
- a. Central Sprinkler Corp.
 - b. ITT Grinnell
 - c. Reliable Automatic Sprinkler Co., Inc.
 - d. Star Sprinkler Corp.
 - e. Viking Corp.
 - f. Victaulic
 - g.

2.2 PIPING MATERIALS AND PRODUCTS

- A. General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, temperature ratings, and capacities as indicated. Where more than one type of materials or products are indicated, selection is Installer's option. A

2.3 BASIC IDENTIFICATION

- A. General: Provide identification complying with Division-22 section "Identification for Plumbing Piping and Equipment".

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2.4 BASIC PIPES AND PIPE FITTINGS

- A. General: Provide pipes and pipe fittings complying with Division-22 section "Pipe, Tube and Fittings for Plumbing Systems", in accordance with the following listing:
1. Pipe Size 2" (50 mm) and Smaller: Black steel pipe; Schedule 40; cast-iron threaded.
 2. Pipe Size 2-1/2" (65 mm) and Larger: Black steel pipe; Schedule 10; welded fittings, ductile iron.
 3. "Weld-o-let" or "Thread-o-let" fittings shall be used for branch/runouts to sprinkler heads.
 4. "U-bolt" clamps, Gruvlok clamps or socket type tees shall not be used and will not be acceptable.

2.5 BASIC VALVES

- A. Gate Valves - 2 Inch (50 mm) and Smaller: Body and bonnet of cast bronze, 175 pound (1200 kPa) cold water working pressure - non-shock, threaded ends, solid wedge. outside screw and Yoke, rising stem, screw-in bonnet, and malleable iron handwheel. Valves shall be capable of being repacked under pressure, with valve wide open.
- B. Gate Valves - 2-1/2 Inch (65 mm) and Larger: Iron body; bronze mounted, 175 pound (1200 kPa) cold water working pressure - non-shock. Valves shall have solid taper wedge; outside screw and Yoke, rising stem; flanged bonnet with body and bonnet conforming to ASTM A 126 Class B; replaceable bronze wedge facing rings; flanged ends; and a packing assembly consisting of a cast iron gland flange, brass gland, packing, bonnet, and bronze bonnet bushing. Valves shall be capable of being repacked under pressure, with valve wide open.
- C. Swing Check Valves: MSS SP-71; Class 175, cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, with a bronze disc or cast iron disc with bronze disc ring, and flanged ends. Valve shall be capable of being refitted while the valve remains in the line.

2.6 AUTOMATIC SPRINKLERS

- A. Sprinkler Heads: Fusible link or glass bulb type, and style as indicated or required by the application. All heads shall be UL/FM approved. For each application, all heads shall be of the same manufacturer. Unless otherwise indicated, provide heads with nominal 1/2 inch (13 mm) discharge orifice, for "Ordinary" temperature range.
- B. Sprinkler Head Finishes: Provide heads with the following finishes:
1. Upright or Pendent Styles: Standard bronze finish for heads in unfinished spaces and not exposed to view. Heads shall be wax-coated where installed exposed to acids, chemicals, or other corrosive fumes.

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2. Recessed Ceiling and Sidewall Styles: Bright chrome, with [bright chrome] [painted white] escutcheon plate.
 3. Concealed Style: Rough brass and painted white cover, screwed-on adjustment plate.
 4. Intermediate Level Style: Bright chrome.
 5. Extended Coverage: bright chrome.
- C. Provide quick response sprinkler heads throughout the building.
- D. Provide high temperature sprinkler heads in equipment spaces where pressure and temperature relief valve(s) are to be installed.
- E. Sprinkler Head Cabinet and Wrench: Finished steel cabinet, suitable for wall mounting, with hinged cover and space for six (6) spare sprinkler heads plus sprinkler head wrench. Provide a separate cabinet for each style sprinkler head on the project.

2.7 FIRE DEPARTMENT VALVE CABINET

- A. Cabinets for fire department valves shall be recessed aluminum with satin anodized finish. Door shall be 1/2" (13 mm) thick (hollow) with full glass window and 1-3/4" (45 mm) face trim. Valve cabinet shall be designed and installed to maintain the integrity of a 2-hour rated wall system in accordance with all applicable codes and standards.

2.8 FIRE DEPARTMENT VALVE

- A. Fire Department valve shall be a 2-1/2" (65 mm) polished brass pressure reducing device capable of handling inlet pressures up to 300 psi (2040 kPa).
- B. Valve shall be complete with removable 2-1/2" x 1-1/2" (65 mm x 40 mm) reducer, cap and chain.

2.9 ALARM DEVICES

- A. General: Types and sizes shall mate and match piping and equipment connections.
- B. Water Flow Indicators: Vane type waterflow detector, rated to 250 psig (1724 kPa); designed for horizontal or vertical installation; have 2-SPDT circuit switches to provide isolated alarm and auxiliary contacts, 7 ampere 125 volts AC and 2.5 ampere 24 Volts DC; complete with factory-set, field-adjustable retard element to prevent false signals, and tamper-proof cover which sends a signal when cover is removed.
- C. Supervisory Switches: SPST, normally closed contacts, designed to signal valve in other than full open position.

1.

PART 3 - EXECUTION

3.1 PIPING INSTALLATIONS

- A. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. So far as practical, installation of piping shall leave adequate space for work of all other trades.
 - 1. Deviations from approved "Working Plans" for sprinkler piping require written approval of the authority having jurisdiction. Written approval shall be on file with the Architect prior to deviating from the approved "Working Plans."
- B. Install sprinkler piping to provide for system drainage in accordance with the most current edition of NFPA 13.
- C. Use approved fittings to make all changes in direction, branch takeoffs from mains, and reductions in pipe sizes. Branch takeoffs to sprinkler heads shall occur from the top of sprinkler branch piping.
- D. Install unions in pipes 2 inch (50 mm) and smaller, adjacent to each valve. Unions are not required on flanged devices. .
- E. Install flanges on valves, apparatus, and equipment having 2-1/2 inch (65 mm) and larger connections..
- F. Hangers and Supports: In addition to the requirements specified in the Division-22 Section "Hangers and Supports for Plumbing Piping and Equipment," comply with the requirements of the most current editions of NFPA 13 and NFPA 14. .. Provide protection from damage where subject to earthquake in accordance with the most current edition of NFPA 13.
- G. Make connections between underground and above-ground piping using an approved transition piece strapped or fastened to prevent separation.
- H. Provide mechanical sleeve seals at pipe penetrations in basement and foundation walls and penetration seals at openings in fire rated walls, floors and ceilings. Refer to Division-22 Section "Piping Specialties for Plumbing Systems" for description and installation requirements.
- I. Install test connections sized and located in accordance with the most current edition of NFPA 13 complete with shutoff valve. Test connections may also serve as drain pipes.
- J. Install pressure gage on the riser or feed main at or near each test connection. Provide gage with a connection not less than 1/4 inch (6 mm) and having a soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and where they will not be subject to freezing.
- K. Piping passing through areas exposed to freezing conditions shall be protected against

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freezing by insulated coverings, frostproof casings or other reliable means capable of maintaining a minimum temperature of 40°F (4°C). All sprinkler piping, heads, fittings, etc. shall be installed on "warm" side of insulation. Insulation shall be tight with no open joints. Piping shall not touch or be run immediately adjacent to building structural steel. Prior to installing piping in areas exposed to freezing, the contractor shall notify the architect or owner's representative.

3.2 PIPE JOINTS

- A. Welded Joints: AWS B2.1, Level AR-3.
- B. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field cut threads. Join pipe, fittings, and valves as follows:
 1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
 2. Align threads at point of assembly.
 3. Apply appropriate tape or thread compound to the external pipe threads.
 4. Assemble joint to appropriate thread depth. When using a wrench on valves place the wrench on the valve end into which the pipe is being threaded.
 5. Damaged Threads: Do not use pipe with threads which are stripped, chipped, corroded, or otherwise damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.
- C. Flanged Joints: Align flanges surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly to appropriate torque specified by the bolt manufacturer.
.
- D. End Treatment: After cutting pipe lengths, remove burrs and fins from pipe ends.

3.3 VALVE INSTALLATIONS

- A. General: Install fire protection specialty valves, fittings, and specialties in accordance with the manufacturer's written instructions, the most current editions of NFPA 13 and 14, and the authority having jurisdiction.
- B. Gate Valves: Install supervised-open gate valves so located to control all sources of water supply except fire department connections. Where there is more than one control valve, provide permanently marked identification signs indicating the portion of the system controlled by each valve. Refer to Division-22 Section "Identification for Plumbing Piping and Equipment" for valve tags and signs.

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- C. Install check valves in each water supply connection.
- D. Fire Department Valves: Install 2-1/2 inch (65 mm) fire department valves with quick-disconnect 2-1/2 to 1-1/2 inch (65 mm to 40 mm) reducing coupling and flow restriction device at each standpipe outlet for hose connections.

3.4 SPRINKLER HEAD INSTALLATIONS

- A. In areas with acoustical tile ceilings, sprinkler heads shall be installed in the center of the ceiling grid.
- B. Use manufacturer supplied tools to prevent damage during installations and as required to maintain UL/FM approval.
- C. Sprinkler Heads: Fusible link type, and style as indicated or required by the application. Unless otherwise indicated, provide heads with nominal 1/2 inch (13 mm) discharge orifice, for "Ordinary" temperature range.
- D. Provide high temperature sprinkler heads in equipment spaces where pressure and temperature relief valve(s) are to be installed.
- E. Provide quick response sprinkler heads throughout the building.
- F. Provide NFPA approved sprinkler head guards in all areas subject to potential damage. Sprinkler head guards shall be provided in the following areas and other similar type spaces subject to potential damage: gymnasiums, multi-purpose rooms, fitness areas, activity rooms, mechanical rooms, electrical rooms, etc.

3.5 FIELD QUALITY CONTROL

- A. Flush, test, and inspect sprinkler piping systems in accordance with the most current edition of NFPA 13.
- B. Flush, test, and inspect standpipe systems in accordance with the most current edition of NFPA 14.
- C. Replace piping system components which do not pass the test procedures specified, and retest repaired portion of the system.

END OF SECTION 210110

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SECTION 220100 - BASIC PLUMBING REQUIREMENTS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS

- A. Unless otherwise modified, provisions of General Conditions, Supplementary Conditions and Division-01 govern work under the Plumbing Divisions.
- B. Contract drawings for plumbing work are diagrammatic, intended to convey scope and general arrangement. Contractor shall review and coordinate routing of new work to clear existing piping, electrical, structure, etc. at no cost to the Owner. All dimensions of existing conditions shall be considered approximate (for information only). All dimensions shall be verified prior to construction.
- C. Contract Document Interpretation/Discrepancies:
 - 1. Should the Contractor discover any discrepancies or omissions on the drawings or in the specifications, he shall notify the Architect/Engineer (A/E) of such conditions prior to the bid date. Otherwise, it will be understood that the drawings and specifications are clear as to what is intended and shall be as interpreted by the A/E.
 - 2. In addition, should any contradiction, ambiguity, inconsistency, discrepancy or conflict appear in or between any of the Contract Documents, the Contractor, shall, before proceeding with the work in question, notify the A/E and request an interpretation. In no case shall he proceed with the affected work until advised by the A/E.
 - 3. If the Contractor fails to make a request for interpretation of discrepancies or conflicts in the drawings or specifications, no excuse will be accepted for failure to carry out the work in a satisfactory manner, as interpreted by the A/E. In all cases, the Contractor will be deemed to have estimated the most stringent materials and methods (i.e. the highest quality materials and most expensive manner of completing the work) unless he has requested and obtained written authorization as to which methods or materials will be required.
 - 4. Each and every trade or subcontractor will be deemed to have familiarized himself with all drawings of this project, including Site/Civil, Architectural, Structural, Mechanical, Electrical, Information Technology, etc. so as to avoid coordination errors, omissions, and misinterpretations. No additional compensation will be authorized for alleged errors, omissions, and misinterpretation, whether they are a result of failure to observe these requirements or not.
- D. The complete set of Architectural, Structural, Civil, Mechanical, and Electrical drawings and specifications apply to this work.

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1.2 SCOPE

- A. The work in Division-22 includes furnishing and installing the plumbing systems complete and ready for satisfactory service.
- B. Requirements specified govern work in all sections of Division-22.

1.3 REFERENCES

- A. References to standards, codes, catalogs and recommendations are latest edition in effect on date of invitation to bid.
- B. Refer to applicable contract drawings, specifications and addenda pertaining to other divisions for conditions affecting work.
- C. Refer to Division-01 for description of alternates.
- D. Refer to Division-01 for description of allowance items.
- E. Refer to Division-01 for description of base bid items.
- F. Refer to Division-01 for description of demolition items.

1.4 DEFINITIONS

- A. Following are definitions of terms and expressions used in this Division:
 - 1. "Approve" - to permit use of material, equipment or methods conditional upon compliance with contract document requirements.
 - 2. "Concealed" - hidden from normal sight; includes work in crawl spaces, above ceilings, and in building shafts.
 - 3. "Directed" - directed by Engineer.
 - 4. "Equal, equivalent" - possessing the same performance qualities and characteristics and fulfilling the same utilitarian function.
 - 5. "Exposed" - not concealed.
 - 6. "Indicated" - indicated in Contract Documents.
 - 7. "Piping" - includes pipe, fittings, valves, supports and accessories comprising a system.
 - 8. "Provide" - furnish and install.
 - 9. "Removable" - detachable from the structure or system without physical alteration of materials or equipment or disturbance to other construction.

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10. "Review" - limited observation or checking to ascertain general conformance with design concepts and general compliance with contract document requirements. Such action does not constitute a waiver or alteration of the contract requirements. Verification of quantities and dimensions shall be the responsibility of the Contractor.
11. "Appurtenances" - a device or assembly installed in the referenced system which performs some useful referenced function in the operation, maintenance, servicing, economy or safety of the system. Some examples include, but are not limited to aerators, anchors, supports, gauges, backflow preventers, expansion tanks, filters, flow controls, heat exchangers, interceptors, meters, pressure reducing valves, relief valves, dampers, separators and similar devices.
12. "Record Documents" - drawings, plans and specifications that indicate the nature and location of work reported by Contractors, but not verified by Consultant. Record documents cannot be considered reliable; as they are based on information reported by the Contractor only and is not verified by the Architect or Engineer (A/E).

1.5 RIGGING REQUIREMENTS

- A. Prior to bidding, the Contractor shall verify that all equipment can be physically rigged to the proposed location without disturbance or dismantling of any existing or new physical obstacles. Should the rigging of any new equipment appear to be an issue, the Contractor shall inform the Architect or Engineer (A/E) seven (7) days prior to the bid date that the rigging of the new equipment may present a problem. Otherwise, the Contractor shall, in accordance with the manufacturer's approval and without voiding warranties and/or certifications, have the equipment "broken down" into sections as required to install the equipment in its proposed location without disturbance or dismantling of any existing or new physical obstacles.
- B. Failure to inform the Architect or Engineer (A/E) seven (7) days prior to the bid of any rigging problems will result in the Contractor accepting full responsibility for all modifications to the equipment or the physical obstacles required to install the equipment in its proposed location without additional cost to the Owner.

1.6 CONTRACTOR'S INSTALLATION DRAWINGS

- A. Prior to fabrication and installation, submit shop drawings (min. scale - 1/4" = 1' - 0") illustrating all plumbing piping, lighting fixtures, cable tray, conduit, expansion loops, supports, alignment guides and fire protection coordinated with each other and with the structure. Installation drawings shall be reviewed by Owner's representative prior to fabrication and installation of any new work and prior to the ordering of any plumbing equipment.
- B. Should the Contractor not provide the coordinated installation drawings required above, the following shall apply:
 1. The Contractor shall accept full and absolute responsibility for the coordination of

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- all project materials and equipment to be installed as indicated on the contract documents.
2. Proposed change orders and/or time extensions will not be accepted for any additional work that results from coordination related changes.
 3. A credit shall be issued to the Owner for the value of the coordinated installation drawings; the value of the credit to the Owner shall be as determined by the A/E.
- C. Computer (CADD) files of mechanical drawings (HVAC, plumbing, etc.) will not be made available to the Contractor for use in the preparation of coordinated drawings, shop drawings or any other use.

1.7 MATERIAL, EQUIPMENT AND SUBSTITUTION REQUIREMENTS

- A. Use products of one manufacturer where two or more items of same kind of equipment are required.
- B. Materials and equipment shall have a record of two (2) years successful field use.
- C. Where a specific manufacturer is listed on the drawings, that manufacturer shall be considered the basis of design for that particular item of equipment. Only the basis of design manufacturer has been verified to meet the project requirements (i.e. dimensions, weights, service clearances, electrical requirements, etc.).
- D. Where the drawings and/or specifications indicate more than one manufacturer for a particular item of equipment, only those listed may submit products and services to be included in the work; manufacturers other than those listed will not be acceptable. Should the contractor choose to use one of the specified manufacturers other than the basis of design, it shall be the responsibility of the contractor to verify that the equipment meets all project requirements including, but not limited to, verification of all dimensions, weights, service clearances, electrical requirements, etc. All changes incurred shall be the responsibility of the contractor and shall be provided at no additional cost to the owner.
- E. Substitutions must be submitted for consideration seven (7) days prior to the original bid date. Consideration of substitutions shall be at the sole discretion of the Engineer. Substitution submittals shall include all information required in the "Submittals" paragraph of this specification section, as well as all other requirements indicated through the Division-22 specifications. Substitutions will not mitigate, in any way, the Contractor's responsibility in complying with the coordination, contract requirements or design intent. Any additional electrical, structural or special requirements, etc. shall be the responsibility of the Contractor. Also, any additional cost incurred as a result of substitution shall be the responsibility of the Contractor.
- F. Nameplate: For each piece of power operated plumbing equipment provide a permanent operational data nameplate indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

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- G. Where items of equipment are indicated as Base Bid on the bid form include in the Bid price the cost of providing the equipment upon which the specification is based. In addition, submit with bid for Owner's consideration the amount to be added or deducted from the base bid for other listed manufacturers' equipment. Owner will advise Contractor within forty-five (45) days after award of contract of his selection.

1.8 MATERIAL AND EQUIPMENT LIST

- A. Within thirty (30) days after award of the contract, submit for Engineer's review a list of subcontractors' and manufacturers' names for items proposed for this project.

1.9 SUBMITTALS

- A. Where the drawings and/or specifications indicate more than one allowable manufacturer for a particular piece of equipment and/or product, only those manufacturers indicated may submit products and services to be included in the work. Unless otherwise indicated, manufacturers other than those listed will not be acceptable.
- B. Submit shop drawings, manufacturer's data and certificates for equipment, materials and finish, and pertinent details for each system where specified in each individual section, and obtain approval before procurement, fabrication, or delivery of the items to the job site. Partial submittals are not acceptable and will be returned without review.
- C. Shop Drawings: Drawings shall include floor plans, sectional views, wiring diagrams, and installation details of equipment. Include equipment spaces identifying and indicating proposed location, layout and arrangement of items of equipment, control panels, accessories, piping, ductwork, and other items that must be shown to assure a coordinated installation. Wiring diagrams shall identify circuit terminals, and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. If equipment is disapproved, drawings shall be revised to show acceptable equipment and be resubmitted. All equipment and/or products shall be submitted by an authorized factory representative of that particular product.
- D. Manufacturer's Data: Submittals for each manufactured item shall be manufacturer's descriptive literature of cataloged products, equipment drawings, diagrams, performance and characteristic curves, and catalog cuts.
- E. Standards Compliance: When materials or equipment must conform to the standards of organizations such as the American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM), National Electrical Manufacturers Association (NEMA), American Society of Mechanical Engineers (ASME), American Gas Association (AGA), American Refrigeration Institute (ARI), and Underwriters' Laboratories (UL), proof of such conformance shall be submitted to the Engineer for review. If an organization uses a label or listing to indicate compliance with a particular standard, the label or listing will be acceptable evidence, unless otherwise specified in the individual sections. In lieu of the label or listing, the Contractor shall submit a certificate from an independent testing

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organization, which is competent to perform acceptable testing. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item conforms to the specified organization's standard. For materials and equipment whose compliance with organizational standards or specifications is not regulated by an organization using its own listing or label as proof of compliance, a certificate of compliance from the manufacturer shall be submitted for review. The certificate shall identify the manufacturer, the product, and the referenced standard and shall simply state that the manufacturer certifies that the product conforms to all requirements of the project specification and of the referenced standards listed.

- F. Contractor shall thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission and coordinate installation requirements for equipment submitted, including a) the verification of equipment weights relative to the existing and/or new structural support system and b) the verification of equipment dimensions relative to existing and/or new architectural conditions. Contractor shall be responsible for correctness of all submittals.
- G. Submittals will be checked only for general conformance with the design concept and are subject to the original contract documents, as well as any corrections and comments noted. Comments noted, if any, will not be considered a complete list of all omissions, deviations and corrections necessary to meet the requirements of the contract documents. The contractor will be responsible to confirm that the final product and installation will be in conformance with the contract documents in their entirety, including the responsibility to fully coordinate all work with other trades and to confirm the correctness of dimensions, quantities, and capacities. Submittal review does not authorize or constitute a change to the contract requirements and does not release the contractor of responsibility to conform to the contract requirements. Requirements of the contract are not waived by review of any and all substitutions. The contractor must fulfill the terms of the contract.
- H. Compliance Review Form: Each equipment submittal must include a Compliance Review Form formatted as follows:
 - 1. Section 1: Certify that the submittal is in complete compliance with the plans and specifications, except for the numbered and footnoted deviations and exceptions as defined herein. Deviations or exceptions taken in a cover letter or by contradiction or omission shall not constitute a release from the requirement that the equipment be in complete compliance with the plans and specifications.
 - 2. Section 2: Provide a detailed paragraph by paragraph annotation of the specification with an individual "C", "D", or "E" noted in the margin, as follows:
 - a. "C" shall mean compliance with no exceptions. Provide a numbered footnote (i.e. C1, C2, C3, etc.) for each comment or clarification.
 - b. "D" shall mean compliance with deviations. For each deviation, provide a numbered footnote (i.e. D1, D2, D3, etc.) with a detailed explanation of how the intent of this specification is to be satisfied.

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- c. "E" shall mean exception. The equipment offered is not in compliance with the specifications. For each exception, provide a numbered footnote (i.e. E1, E2, E3, etc.) with a detailed description of the exception.
- I. Electronic Submittals: Should the contractor elect to submit electronic shop drawings/submittals, the procedure shall be as follows:
 - 1. Provide a transmittal with the electronic shop drawing/submittal indicating that the document was transmitted electronically. Transmittal shall also include verification of the contractor's review indicating compliance with the contract documents in accordance with paragraph 1.09.F of this section.
 - 2. Sequentially number all pages on the electronic shop drawing/submittal. The total number of pages shall be reflected in the transmittal.
 - 3. Submittal review comments shall be transmitted electronically. Large documents will be scanned with comments as necessary and returned electronically.
 - 4. All shop drawings such as, but not limited to: coordination drawings, ductwork shop drawings, fire alarm drawings, ductbank layouts, etc. shall be submitted in hard copy, full size format.
 - 5. Provide hard copy of the shop drawing/submittal for each of the Operations and Maintenance Manuals.
 - 6. Failure to comply with the above will result in the submittal being returned and marked "Not Reviewed".
- J. Submittals will be reviewed for general compliance with design concept in accordance with contract documents. Dimensions, quantities, weights, or other details will not be verified by the A/E; this is the responsibility of the Contractor.
- K. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted.
- L. Review Period: BKM shall be allotted two (2) weeks for the processing, review and return of all submittals. It shall be incumbent upon the Contractor to include this time period in their schedule.
 - 1. Resubmittals: BKM shall be allotted an additional two weeks (14 days) for the review of each resubmittal. Again, it shall be the Contractor's responsibility to submit the appropriate materials in a timely fashion.
 - 2. Contract Extension: No extension in contract time will be authorized as a result of the timeline addressed above.
- M. Submittal Identifications:
 - 1. Place a permanent label or title block on each submittal for identification.
 - 2. Indicate name of firm or entity that prepared each submittal on label or title block.

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3. Provide a space approximately 4 by 5 inches on label or beside title block to record contractor's review and approval markings and action taken by A/E.
4. Include the following information on label for processing and recording action taken:
 - a. Project name
 - b. Date
 - c. Name and address of A/E
 - d. Name and address of contractor
 - e. Name and address of subcontractor
 - f. Name and address of supplier
 - g. Name of manufacturer
 - h. Unique identifier, including revision number
 - i. Number and title of appropriate specification section
 - j. Drawing number and detail references, as appropriate
 - k. Other necessary identification
 - l. Example: 220700-01-0
 - 1) 220700 references the spec section
 - 2) 01 indicates this is the first submittal from this spec section
 - 3) 0 indicates this is the original submittal (where 1 would indicate this is the first re-submittal)
- N. The engineer will provide a maximum of two (2) submittal reviews per equipment submittal; the initial review plus one (1) re-submittal. Should the re-submittal be returned "Not Acceptable" or "Revise and Resubmit", the contractor shall choose one of the following courses of action:
 1. Provide the exact manufacturer and model indicated in the contract documents as the basis of design, or
 2. Reimburse the engineer for all additional review time required to achieve a submittal review from the engineer of "No Exceptions Taken."
 3. Should the contractor choose option 2 above, the engineer shall be reimbursed at an hourly rate of \$175 per hour with payment due prior to the return of the final submittal. In addition, the contractor shall accept complete responsibility for all delays resulting from the submittal review process extending beyond two (2)

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reviews per equipment submittal.

- O. Resubmittals: Resubmittals shall comply with paragraph 1.09 of this section and the following additional requirements.
1. Resubmittals shall include a written response to each submittal comment. Provide a detailed comment by comment annotation of the submittal review comments with an individual "C", "D", or "E" as follows:
 - a. "C" shall mean compliance with no exceptions. Provide a numbered footnote (i.e. C1, C2, C3, etc.) for each comment or clarification.
 - b. "D" shall mean compliance with deviations. For each deviation, provide a numbered footnote (i.e. D1, D2, D3, etc.) with a detailed explanation of how the intent of this specification is to be satisfied.
 - c. "E" shall mean exception. The equipment offered is not in compliance with the specifications. For each exception, provide a numbered footnote (i.e. E1, E2, E3, etc.) with a detailed description of the exception.

1.10 MANUFACTURER'S RECOMMENDATIONS

- A. Installation procedures are required to be in accordance with the recommendations of the manufacturer of the material being installed.

1.11 ACCESSIBILITY

- A. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing.

1.12 SAFETY REQUIREMENTS

- A. Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts located so that any person can come in close proximity thereto shall be fully enclosed or properly guarded in accordance with OSHA. High-temperature equipment and piping so located as to endanger personnel or create a fire hazard shall be properly guarded or covered with insulation of a type as specified herein. Items such as catwalks, ladders, and guardrails shall be provided where required for safe operation and maintenance of equipment.

1.13 WORKMANSHIP

- A. Remove and replace, at no extra cost, all work not orderly, reasonably neat, or workmanlike.

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- B. Coordinate all work and cooperate with other trades to facilitate execution of work.

1.14 SITE EXAMINATION/EXISTING CONDITIONS VERIFICATION

- A. Failure to visit site and become familiar with existing conditions prior to bidding will not relieve the Contractor of responsibility for complying with the Contract documents.
- B. Contractor shall field verify existing services and direction of flow of piping prior to connection. Existing plumbing identification shall not constitute proper verification of service or direction of flow.

1.15 REGULATIONS AND PERMITS

- A. Comply with all applicable codes and regulations.
- B. All equipment provided shall be in accordance with all applicable local, state, and federal codes, guidelines and standards, as well as the authority having jurisdiction. Equipment and installation shall be in compliance with all applicable energy codes including the most current version of ASHRAE Standard 90.1.
- C. Obtain and pay for all required permits.

1.16 UTILITY CONNECTIONS

- A. Area connection charges for water and sewers will be paid by the Owner.
- B. Application for water meter will be made by the Owner.
- C. Contractor shall include an allowance as identified in Division-01 for providing water meter, vault, and connection to main by Bureau of Water Supply.

1.17 CUTTING AND PATCHING

- A. Unless otherwise directed, do all cutting and patching. Damaged work, including fireproofing and waterproofing shall be repaired by skilled mechanics of the trade involved.
- B. Do not cut walls, floors, roofs, reinforced concrete or structural steel without structural Engineer's permission. Install services without affecting reinforcing steel.
- C. In precast concrete plank drill all holes with a Carboloy tipped drill. Follow instructions of structural Engineer. Cut no reinforcing bars.

1.18 LINTELS

- A. Under this Section provide all lintels not provided elsewhere which are required for openings for the installations of mechanical and plumbing work. Lintels shall meet the

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requirements of the structural sections.

1.19 CLEANING UP

- A. Keep premises free from accumulation of debris.
- B. Remove tools, scaffolding, surplus material, debris, and leave premises broom clean.
- C. On discontinuance of part of the work, place all debris in containers and promptly remove them from the Owner's property.
- D. Leave all areas broom clean.
- E. Final clean-up shall be performed.

1.20 AREAS REQUIRING SPECIAL FINISHES/PAINTING

- A. In kitchens, cafeterias, dining rooms, serving pantries and utility rooms [polish chromium or nickel plate] [paint as specified under Painting] all exposed and uninsulated piping including valves, traps, strainers and appurtenant items; and exposed electrical work including conduit, boxes, switches starters and disconnects. Finish shall not be applied to nameplates, pushbuttons. Stainless steel housing and plates require no plating or paints.
- B. Provide surface preparation, priming and painting of all mechanical room floors to provide a smooth, cleanable surface. Primer and paint shall be appropriate for concrete slab surfaces. Where painting over existing surfaces or coatings, follow manufacturer's recommendations for surface preparation, priming and painting. Architectural section "Painting" shall govern the painting installation. Color shall be selected by Architect.

1.21 PROTECTION

- A. Protect mechanical and electrical material and equipment from the elements or other injury as soon as delivered on premises. Protect fixtures as soon as they are set. Board over water closets and post notices prohibiting their use.
- B. Cap or plug openings in equipment, piping and conduit systems to exclude dirt and other foreign material. Rags, wool, cotton, paper, waste or similar materials shall not be used for plugging.
- C. Contractor shall protect all existing mechanical, electrical and architectural equipment, materials, finishes, etc. located within or adjacent to the work environment. Contractor shall be responsible for restoration of all existing mechanical, electrical and architectural items to remain. All equipment to remain must be restored to its pre-existing condition prior to the start of work. Restoration and/or replacement shall be at no cost to the Owner.
- D. Contractor shall provide temporary cooling and heating as required to protect all

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construction materials from the potential adverse effects of high or low temperature and humidity. Upon delivery of ceiling and other finish materials to a location within the building, environmental conditions in all spaces where the materials will be either stored or installed shall be permanently maintained at 75°F (+2°F) and 50% RH (+5%). Should the HVAC include a reheat system, the reheat system shall be energized to provide temperature and humidity control whenever the HVAC system is energized. Contractor shall pay for all utility, fuel, operational, maintenance and repair costs associated with providing the environmental conditions indicated above until the owner accepts occupancy of the building.

1.22 PIPE TESTING

- A. Prior to the balancing of systems, the mechanical contractor shall air and/or hydrostatically test the following systems in accordance with the latest ASME B31 (ASME Code for Pressure Piping) and NFPA requirements.
 - 1. Hydrostatic Test:
 - a. Domestic Water
- B. Pressure tests shall also be performed prior to the installation of all insulation materials.
- C. Hydrostatic Test: Provide temporary equipment for testing, including pump and gages. Test piping system before insulation is installed, wherever feasible and remove control devices before testing. Test each natural section of each piping system independently, but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with water and pressurize for indicated pressure and time.
 - 1. Required test period is four (4) hours.
 - 2. Hydrostatically test each piping system at 150% of operating pressure indicated, but not less than 100 psi (690 kPa) test pressure.
 - 3. Observe each test section for leakage at end of test period. Test fails if leakage is observed or if pressure drop exceeds less than one percent (1.0%) of test pressure.
 - 4. Upon completion of roughing-in and before setting fixtures, the entire new domestic water system shall be tested. Where a portion of the water piping system is to be concealed before completion, this portion shall be tested separately in a manner described for the entire system.
 - 5. Prior to testing, verify the pressures listed above are in accordance with the latest ASME B31 code and NFPA. Should a discrepancy exist between the ASME B31 code, NFPA, and/or the pressures indicated above, contact the Engineer prior to testing.
- D. Sanitary and Storm Water Piping Systems:

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1. All soil, waste, vent and storm water piping shall be tested by the Contractor and reviewed by the Architect before acceptance. All piping located underground shall be tested before backfilling. The costs of all equipment required for tests are to be included under the contract price.
 2. The entire new drainage system and venting system shall have all necessary openings plugged and filled with water to the level of the highest vent stack above the roof. The system shall hold this water for four (4) hours without showing a drop in water level. Where a portion of the system is to be tested, the test shall be conducted in the same manner as described for the entire system, except a vertical stack 10 feet (3000 mm) above the highest horizontal line to be tested may be installed and filled with water to maintain sufficient pressure, or a pump may be used to supply the required pressure.
- E. Drain test water from piping systems after testing and repair work has been completed.
- F. Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.

1.23 CLEANING OF SYSTEMS

- A. After satisfactory completion of pressure tests and before permanently connecting fixtures, equipment, traps, strainers and other accessory items, thoroughly clean all systems. Blow out and flush piping until interiors are free of foreign matter.
- B. Flush piping in recirculating water systems to remove all cutting oil, excess pipe joint compound and other foreign materials. Furnish necessary temporary pumping equipment to thoroughly clean the water piping. Do not use any system pump until after cleaning and flushing has been accomplished to the satisfaction of the Engineer. Employ chemical cleaners, including a non-foaming detergent, not harmful to system components. After cleaning operation, final flushing and refilling the residual alkalinity shall not exceed 300 parts per million. Work shall be performed or supervised by a qualified water treatment service company with personnel skilled in the safe and proper use of chemicals and in testing procedures. After completion, submit a certificate of completion to Engineer stating name of the service company used.
- C. Leave strainers and dirt pockets in clean condition.
- D. Should any system become clogged with construction refuse after acceptance, the contractor shall pay for all labor and materials required to locate and remove the obstruction and replace and repair work disturbed.
- E. Thoroughly clean plumbing fixture using non-scratching cleaners. Polish chromium plated work.
- F. Leave all systems clean, and in complete running order.
- G. Disinfect potable water systems as prescribed by local code. Take precautions to avoid use of fixtures during disinfection period.

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- H. Equipment that has been subjected to the elements shall be cleaned of all rust, dirt and debris and repainted to match original finish.

1.24 FUNCTIONAL PERFORMANCE TESTING AND VERIFICATION

- A. General: In addition to the tests required during and after installation of all mechanical systems, as well as any other formal commissioning requirements, the Contractor shall perform functional performance tests to verify that all systems are designed, installed, calibrated and adjusted to perform as required in the Contract.
- B. Comply with all applicable specification sections including, but not be limited to, "Basic Plumbing Requirements", "Testing, Adjusting and Balancing", "Automatic Temperature Controls" and "Commissioning", where applicable.
- C. Prior to functional performance testing, all indicating, recording and control devices shall be calibrated. A verification calibration report shall be provided with the final test report.
- D. Provide functional performance testing to verify proper operation of each and every control sequence indicated throughout the contract documents.
- E. Failure of Tests: Should any test, verification, or demonstration fail to meet the specification requirements, the component of the system causing the failure shall be repaired, replaced or readjusted. The failed test, verification, or demonstration shall then be repeated.
- F. A "Functional Performance Test Verification Form" is included at the end of Section 230900. This form (electronic version is available upon request) shall be completed for all mechanical equipment provided under this contract.
- G. Test Report: Upon satisfactory verification of calibration and functional performance tests, a copy of the final test results shall be bound in the operations and maintenance manual. The final report shall also include a full compliance statement, on company letterhead, indicating that all systems are installed and functioning per the contract requirements including drawings, specifications, control sequences and accepted submittals.
- H. The mechanical systems shall not be considered complete until all functional performance verification forms, calibration reports and compliance statement have been submitted and reviewed. Submit in accordance with the submittal requirements indicated elsewhere in these specifications.

1.25 OPERATING AND MAINTENANCE MANUAL

- A. Submit Operation and Maintenance Manuals in three-ring binders with each section separated by tab dividers. Include protective plastic sleeves for any software or folded large documents submitted.
- B. At a minimum, the manual shall contain the following:

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1. Title page
 2. Table of contents
 3. Contractor and sub-contractor contact information
 4. Supplier contact information for all plumbing equipment
 5. Copies of manufacturer's and contractor's warranty information (project and equipment) for all plumbing equipment.
 6. Submittal log for all plumbing equipment
 7. One (1) reviewed copy of each shop drawing or submittal incorporating all A/E and owner submittal review comments.
 8. Copy of inspector acceptance certificates / documents.
 9. Provide an 11 x 17 fold-out drawing of each floor plan and indicate locations of system shutoff valves.
 10. All pipe and equipment pressure test reports complete with 11 x 17 fold-out drawing, indicating all systems tested.
 11. Maintenance procedures for each item of plumbing equipment to include frequency and type of maintenance, spare parts and attic/stock list. This shall include the manufacturer's literature indicating operating and maintenance instructions, parts list, illustrations and diagrams.
 12. Valve tag chart
 13. Mechanical systems functional performance verification forms, calibration reports and compliance statement indicating that all systems are installed and functioning per the contract requirements.
- C. The O & M Manuals shall be submitted to the A/E for review of general conformance.

1.26 TOOLS AND LUBRICANTS

- A. Furnish and turn over to the Owner, special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.
- B. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.
- C. Tool Containers: Hardwood or metal, permanently identified for intended service and mounted, or located, where directed by the Owner.
- D. Lubricants: A minimum of one quart (.9 L) of oil, and one pound (450 g) of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

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1.27 FIELD INSTRUCTION

- A. Upon completion of work, instruct Owner's representative in the proper operation and maintenance of the plumbing and electrical systems.
- B. Instruction periods specified below shall be in addition to instruction specified for certain items elsewhere in the specifications.
- C. Instructions shall be given by persons expert in the operation and maintenance and shall be for a period of not less than (1) eight hour day.
- D. Prepare statement(s) for signing by Owner's representative indicating date of completion of instructions and hours expended. Furnish copy of signed statement to Engineer.
- E. Final demonstration of all plumbing equipment shall be recorded in DVD compatible format. Provide DVD's to the Owner.

1.28 RECORD DOCUMENTS

- A. The Contractor shall maintain a record set of plumbing prints at the project site and shall indicate thereon any changes made to the contract drawings, including, but not limited to addenda, field sketches, RFI responses, supplemental drawings, sketches, etc. Where changes are made that are reflective of supplemental instructions, revisions, RFI responses, etc., the Contractor shall make clear references to those changes.
- B. A separate set of neat, legible mechanical contract prints shall be kept at the project site at all times during the construction of the work for the express purpose of showing any and all changes indicated in paragraph A. above. The prints shall be marked up daily showing all changes to the original documents. The prints shall be marked up in a neat, legible manner using a red pen. Periodic review of the Record Documents will be conducted by the Owner's Representative or A/E. Should this review indicate that the Record Documents are deficient or not up to date, the Contractor shall immediately bring the documents into compliance and make the corrections
- C. Upon completion of the project and before final close-out, the Contractor shall be responsible for producing a final set of record documents in electronic CADD format. One (1) set of full size prints, one (1) CD of the electronic CADD drawings (in AutoCad and pdf format), along with the red-lined marked up field set shall be delivered to the owner upon completion. If requested, the electronic CADD documents shall be uploaded to the owner's FTP site. The final CADD documents shall indicate in the title or revision block "RECORD DOCUMENTS" along with the date completed. The electronic format shall be compatible with the owner's preferred version of AutoCad. Coordinate with the owner before producing the CD or up-loading to the FTP site. Not acceptable are contractor installation drawings, shop drawings or multi-layers of work on a single drawing. The final as-built product shall mirror the contract bid documents using the project page layout, format and project title block.
- D. Computer (CADD) files of plumbing drawings will be made available to the Contractor upon receipt of a signed waiver (available upon request). One CD will be made available to the general contractor or construction manager for distribution to the trades.

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- E. Should the Contractor's electronic Record Documents not be considered complete, they will be returned for completion and/or correction.

1.29 DEMOLITION

- A. All demolition of existing mechanical and electrical piping, auxiliaries and equipment, shall be as specified under the Architectural "Demolition" section, of these specifications, as shown on the drawings, and as required to complete the new and renovated installations and shall be performed by the respective mechanical and electrical contractors.
- B. This work shall include the disconnection and capping of existing services, relocation of certain equipment, and the removal of existing piping, wiring, fittings, equipment, including heat transfer units, plumbing fixtures, electrical controls and panelboxes, etc., not reused in the new work or required to complete the renovation work. Contractor shall note the drawings specify certain existing equipment to be reused.
- C. Where supports and piping are removed, holes remaining in floors, walls and ceilings must be patched and refinished to match the adjoining original surfaces and finishes.
- D. Any removed items requested by the Owner shall remain the property of the Owner. Contractor shall remove equipment and store on site as directed by the Owner. All other equipment or material shall become the property of the Contractor and shall be removed from the site. Contractor shall meet Federal EPA Laws, Regulations and Guidelines in regard to removal of asbestos insulation.
- E. The contractor shall use care when performing selective building and site demolition. The contractor shall be responsible for damage inclusive of but not limited to: building finishes, lighting (interior and exterior), furniture, structure, site, utilities (above and below ground), mechanical, plumbing, telecommunications and electrical equipment / systems. Should any damage occur or should any remedial work be required, the contractor shall be responsible to repair and or replace the damaged item(s) to the Owner's satisfaction at no additional cost. The contractor shall be responsible for surveying (including contacting Miss Utility), photo documenting and restoring the surrounding work site(s) to the original pre-demolition condition and / or to the Owner's satisfaction upon completion of the work at no additional cost.

1.30 OUTAGES

- A. All plumbing outages which will interfere with the normal use of the building in any manner shall be done at such times as shall be mutually agreed upon by the Contractor and the Owner's Representative.
- B. Unless otherwise specified, outages of any services required for the performance of this contract and affecting areas other than the immediate work area shall be scheduled at least ten (10) days in advance with the Owner's Representative. All such outages shall be performed during other than normal duty hours.
- C. The Contractor shall include in his price the cost of all premium time required for outages

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and other work which interferes with the normal use of the building, which will be performed, in most cases, during other than normal work time and the convenience of the using agency.

1.31 LEAD FREE COMPLIANCE

- A. Lead Free Compliance: All components associated with potable water systems (including, but not limited to, valves, end use devices/fixtures, pipe, pipe fittings, solder/flux, etc.) shall be "lead-free" in accordance with all local, state and federal codes, as well as NSF/ANSI 372 (NSF 61-G).

1.32 LEED CERTIFICATION

- A. This project is required to obtain a LEED certification. The Contractor shall provide all required LEED documentation as required to achieve the construction related LEED credits.
- B. The project includes both LEED Fundamental and Enhanced Commissioning. Provide all services as required for compliance with the Fundamental and Enhanced Commissioning requirements. Coordinate with the Commissioning Agent as required. Refer to the Commissioning specification sections for additional information.

1.33 GUARANTEE/WARRANTY

- A. Each Contractor shall furnish a guarantee covering all labor and materials furnished by him for a period of two (2) years from the date of final acceptance of his work, and he shall agree to repair and make good at his own expense any and all defects which may appear in his work during that time if, in the judgment of the Engineer, such defects arise from defective workmanship and/or imperfect or inferior material.
- B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or warranty. Certificates of guarantee shall be delivered to the Owner.
- C. Within the two (2) year warranty/guarantee period, manufacturer's recommended maintenance shall be provided by the Contractor.

1.34 PIPING LEAKAGE TEST FORMS

- A. Contractor shall submit piping leakage test results to the A/E within 72 hours of completed tests. Only test results that meet the specified leakage requirements shall be submitted. Piping test results shall be recorded on the "Piping Leakage Test Summary Form (Plumbing)" located at the end of this section; no other forms will be accepted. In addition, the pipe leakage submittals shall include 11x17 drawing(s) as required to clearly indicate the full extent of the piping test section (each piping test section shall be numbered and color coded).

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PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

Not Applicable

END OF SECTION 220100

PIPING LEAKAGE TEST SUMMARY FORM
(PLUMBING)

Project Name:

Project
Number:

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System Tested	Sections Tested (1)	System Operating Pressure	Test Pressure (PSI/FT-HD) (2)	Duration (3)	Pressure Drop (4)	Pass/Fail

Name of Testing Agency/Company: _____

Date of Test(s): _____

Test Conducted By (Print/Sign): _____

- (1) Identified by an 11 x 17 numbered and color coded test section plan. Plan shall accompany this test report.
- (2) 150% of operating pressure but not less than 100 psi , 200 psi for air-gas-vacuum, 10 ft. static head pressure or to the maximum rating of the joint. Include joint cut sheets showing their ratings.
- (3) Four (4) hours minimum.
- (4) Shall not exceed 0.0%.

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SECTION 220200 - PROJECT CLOSEOUT PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

- A. This section provides a summary of the primary mechanical project closeout activities, however, this section does not attempt to address all project closeout requirements. Closeout activities referenced in this section include the following:
 - 1. Pressure Testing
 - 2. Start-up
 - 3. Punch-out Procedures
 - 4. Testing, Adjusting and Balancing
 - 5. Functional Performance Testing and Verification
 - 6. Operation and Maintenance Manuals (O & M Manuals)
 - 7. Demonstration and Training
 - 8. Record Documents
 - 9. Close-out Documents
- B. This Section shall not supersede any other close-out section or requirements of the Contract. Refer to other Divisions of the specifications and the General Requirements of the Contract for further instructions.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

3.1 PRESSURE TESTING

- A. Piping: The Contractor shall perform pressure testing on all piping systems.
- B. Final pressure test results shall be submitted as a separate project submittal for review and included with the Test and Balance Report. Upon review for general conformance, include all pressure tests in the O & M Manual.

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- C. All factory performed equipment test results shall be included in the final O & M Manuals.
- D. Where re-tests were required, indicate remedial action taken and submit in test report.

3.2 START-UP

- A. The Contractor shall perform start-up on each piece of mechanical equipment as specified in each section of Division-22.
- B. Where indicated in each section of Division-22, the services of a factory authorized and certified technician shall be required to perform the equipment start-up. Start-up by any other organization other than as required by the manufacturer is unacceptable.
- C. Start-up reports shall be provided for all equipment and be included in the final O & M Manuals.

3.3 PUNCH-OUT PROCEDURES

- A. Preliminary Punch-out:
 1. Prior to requesting an inspection from the Owner, Engineer, or Permit Official, the General Contractor or Construction Manager (GC or CM) shall provide a preliminary punch-out of the area in question.
 2. Once completed, their punch list shall be supplied to each trade for corrections and completion. The punch list shall also be provided to the Engineer for their use.
 3. Upon being informed that the trade contractors have addressed all of the outstanding items, the GC / CM shall backcheck the work and update the punch list.
- B. Final Punch-out:
 1. Final punch-out by the engineer shall not commence until the GC or CM has exhausted their review and has signed off on all items.
 2. A copy of the sign-off shall be provided to the Engineer for their record.
 3. Once the above has been completed, the Engineer shall be notified that the work is substantially complete and ready for a final punch-out.
 4. Depending on the size, schedule, and project complexity, punch-outs may be requested for specific areas or systems, rather than the facility as a whole. Examples of specific requests include the following:
 - a. Above ceiling
 - b. Mock-ups for any repetitive installation to confirm acceptance prior to continuing (labs, dorms, offices, etc.)

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- c. Equipment rooms
- C. Upon completion of any and all punch lists (i.e. above ceiling, final, partial, phased, factory review, or specific item) the contractor shall provide an item by item sign-off indicating the date and who completed the item. The sign-off shall be submitted to the A/E and owner before final payment is processed. Should the contractor disagree with any item, they shall provide a written exception giving reason for review.

3.4 TESTING, ADJUSTING AND BALANCING

- A. Comply with all provisions of Division-23 Section, "Testing, Adjusting and Balancing" (TAB) for the systems listed, but not limited to, the following:
1. Domestic hot water recirc pump and associated balance valves
- B. TAB reports shall be submitted as a separate project submittal for review. Upon review for general conformance, include the final TAB report in the O & M Manual.

3.5 FUNCTIONAL PERFORMANCE TESTING AND VERIFICATION

- A. General: In addition to the tests required during and after installation of all mechanical systems, as well as any other formal commissioning requirements, the Contractor shall perform functional performance tests to verify that all systems are designed, installed, calibrated and adjusted to perform as required in the Contract.
- B. Comply with all applicable specification sections including, but not be limited to, "Basic Plumbing Requirements", "Testing, Adjusting and Balancing", "Automatic Temperature Controls" and "Commissioning", where applicable.
- C. Prior to functional performance testing, all indicating, recording and control devices shall be calibrated. A verification calibration report shall be provided with the final test report.
- D. Provide functional performance testing to verify proper operation of each and every control sequence indicated throughout the contract documents.
- E. Failure of Tests: Should any test, verification, or demonstration fail to meet the specification requirements, the component of the system causing the failure shall be repaired, replaced or readjusted. The failed test, verification, or demonstration shall then be repeated.
- F. A "Functional Performance Test Verification Form" is included at the end of Section 230900. This form (electronic version is available upon request) shall be completed for all mechanical equipment provided under this contract.
- G. Test Report: Upon satisfactory verification of calibration and functional performance tests, a copy of the final test results shall be bound in the operations and maintenance manual. The final report shall also include a full compliance statement, on company letterhead, indicating that all systems are installed and functioning per the contract

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requirements including drawings, specifications, control sequences and accepted submittals.

- H. The mechanical systems shall not be considered complete until all functional performance verification forms, calibration reports and compliance statement have been submitted and reviewed. Submit in accordance with the submittal requirements indicated elsewhere in these specifications.

3.6 OPERATION AND MAINTENANCE MANUALS

- A. Submit Operation and Maintenance Manuals in three-ring binders with each section separated by tab dividers. Include protective plastic sleeves for any software or folded large documents submitted.
- B. At a minimum, the manual shall contain the following:
1. Title page
 2. Table of contents
 3. Contractor and sub-contractor contact information
 4. Supplier contact information for all mechanical equipment
 5. Copies of manufacturer's and contractor's warranty information (project and equipment) for all mechanical equipment.
 6. Submittal log for all mechanical equipment
 7. One (1) reviewed copy of each shop drawing or submittal incorporating all A/E and owner submittal review comments.
 8. Copy of inspector acceptance certificates / documents.
 9. Provide an 11 x 17 fold-out drawing of each floor plan and indicate locations of system shutoff valves.
 10. All pipe and equipment pressure test reports complete with 11 x 17 fold-out drawing, indicating all systems tested.
 11. Final Test and Balance (TAB) Reports. Do not include reports that have not been accepted by the A/E. Pencil or partial copies will not be acceptable.
 12. Maintenance procedures for each item of mechanical equipment to include frequency and type of maintenance, spare parts and attic/stock list. This shall include the manufacturer's literature indicating operating and maintenance instructions, parts list, illustrations and diagrams.
 13. Valve tag chart
 14. Mechanical systems functional performance verification forms, calibration reports

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and compliance statement indicating that all systems are installed and functioning per the contract requirements.

- C. The O & M Manuals shall be submitted to the A/E for review of general conformance.

3.7 DEMONSTRATION AND TRAINING

- A. Upon completion of work, instruct the owner's representative in the proper operation and maintenance of each mechanical system in accordance with applicable specification sections.
- B. Instructions shall be given by persons expert in the operation and maintenance of each system / equipment.
- C. Prepare statement(s) for signing by Owner's representative indicating the date of completion of instructions and hours expended. Furnish copies of signed statements to the A/E.
- D. Final demonstration of all mechanical equipment shall be recorded in DVD compatible format. Provide DVDs to the Owner.

3.8 RECORD DOCUMENTS

- A. The Contractor shall maintain a record set of plumbing prints at the project site and shall indicate thereon any changes made to the contract drawings, including, but not limited to addenda, field sketches, RFI responses, supplemental drawings, sketches, etc. Where changes are made that are reflective of supplemental instructions, revisions, RFI responses, etc., the Contractor shall make clear references to those changes.
- B. A separate set of neat, legible mechanical contract prints shall be kept at the project site at all times during the construction of the work for the express purpose of showing any and all changes indicated in paragraph A. above. The prints shall be marked up daily showing all changes to the original documents. The prints shall be marked up in a neat, legible manner using a red pen. Periodic review of the Record Documents will be conducted by the Owner's Representative or A/E. Should this review indicate that the Record Documents are deficient or not up to date, the Contractor shall immediately bring the documents into compliance and make the corrections
- C. Upon completion of the project and before final close-out, the Contractor shall be responsible for producing a final set of record documents in electronic CADD format. One (1) set of full size prints, one (1) CD of the electronic CADD drawings (in AutoCad and pdf format), along with the red-lined marked up field set shall be delivered to the owner upon completion. If requested, the electronic CADD documents shall be uploaded to the owner's FTP site. The final CADD documents shall indicate in the title or revision block "RECORD DOCUMENTS" along with the date completed. The electronic format shall be compatible with the owner's preferred version of AutoCad. Coordinate with the owner before producing the CD or up-loading to the FTP site. Not acceptable are contractor installation drawings, shop drawings or multi-layers of work on a single

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- drawing. The final as-built product shall mirror the contract bid documents using the project page layout, format and project title block.
- D. Computer (CADD) files of plumbing drawings will be made available to the Contractor upon receipt of a signed waiver (available upon request). One CD will be made available to the general contractor or construction manager for distribution to the trades.
 - E. Should the Contractor's electronic Record Documents not be considered complete, they will be returned for completion and/or correction.

3.9 CLOSEOUT DOCUMENTS

- A. Prior to Substantial Completion and /or Final Payment, the Contractor shall prepare and submit the following:
 - 1. Final punch lists indicating completion of all items
 - 2. All record drawings
 - 3. All record specifications
 - 4. Operation and Maintenance Manuals
 - 5. Complete final cleaning
 - 6. Remove temporary facilities and complete site restoration

END OF SECTION 220200

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SECTION 220500 - BASIC PLUMBING MATERIALS AND METHODS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-01 Specification Sections, apply to this Section.
- B. Requirements specified in all Division-22 sections apply to this Section.

1.2 SUMMARY

- A. This Section includes limited scope general construction materials and methods for application with mechanical installations as follows:
 - 1. Mechanical equipment nameplate data.
 - 2. Firestopping: Provide seals for all openings through fire-rated walls, floors, or ceilings used as passage for mechanical and electrical components such as piping, conduit, etc.
 - 3. Selective demolition including:
 - a. Nondestructive removal of materials and equipment for reuse or salvage as indicated.
 - b. Dismantling mechanical materials and equipment made obsolete by these installations.
 - 4. Excavation for underground utilities and services, including underground piping (under the building and from building to utility connection), tanks, basins, and equipment up to five (5) feet (1500 mm) outside the building.
 - 5. Miscellaneous metals for support of mechanical materials and equipment.
 - 6. Wood grounds, nailers, blocking, fasteners, and anchorage for support of mechanical materials and equipment.
 - 7. Joint sealers for sealing around mechanical materials and equipment; and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
 - 8. Access panels and doors in walls, ceilings, and floors for access to mechanical materials and equipment.

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1.3 DEFINITIONS

- A. The following definitions apply to excavation operations:
 - 1. Additional Excavation: Where excavation has reached required subgrade elevations, if unsuitable bearing materials are encountered, continue excavation until suitable bearing materials are reached. The Contract Sum may be adjusted by an appropriate Contract Modification.
 - 2. Subbase: As used in this Section refers to the compacted soil layer used in pavement systems between the subgrade and the pavement base course material.
 - 3. Subgrade: As used in this Section refers to the compacted soil immediately below the slab or pavement system.
 - 4. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction from the Architect.
- B. The following definitions apply to firestopping:
 - 1. Assembly: Particular arrangement of materials specific to given type of construction described or detailed in referenced documents.
 - 2. Barriers: Time rated fire walls, smoke barrier walls, time rated ceiling/floor assemblies and structural floors.
 - 3. Firestopping: Methods and materials applied in penetrations and unprotected openings to limit spread of heat, fire, gases and smoke.
 - 4. Penetration: Opening or foreign material passing through or into barrier or structural floor such that full thickness of rated materials is not obtained.
 - 5. Construction Gaps: Gaps between adjacent sections of walls, exterior walls, at wall tops between top of wall and ceiling, and structural floors or roof decks; and gaps between adjacent sections of structural floors.
 - 6. System: Specific products and applications classified and numbered by Underwriters Laboratories, Inc. to close specific barrier penetrations.
 - 7. Sleeve: Metal fabrication or pipe section extending through thickness of barrier and used to permanently guard penetration. Sleeves are described as part of penetrating system in other sections and may or may not be required.

1.4 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division-01 Specification Sections.
- B. Product data for the following products:

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1. Access panels and doors
 2. Joint sealers
- C. Firestopping: Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures.
1. Provide details of each proposed assembly identifying intended products and applicable UL system number, or UL classified devices.
 2. Provide drawings relating to non-standard applications as needed.
- D. Shop drawings detailing fabrication and installation for metal fabrications, and wood supports and anchorage for mechanical materials and equipment.
- E. Coordination drawings for access panel and door locations in accordance with Division-22 sections.
- F. Samples of joint sealer, consisting of strips of actual products showing full range of colors available for each product.
- G. Welder certificates, signed by Contractor, certifying that welders comply with requirements specified under "Quality Assurance" article of this Section.
- H. Schedules indicating proposed methods and sequence of operations for selective demolition prior to commencement of Work. Include coordination for shut-off of utility services and details for dust and noise control.
1. Coordinate sequencing with construction phasing and Owner occupancy specified in Division-01 Section "Summary of Work."

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an Installer for the installation and application of joint sealers, access panels and doors, and firestopping materials with at least two years' experience with installations.
- B. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."
- C. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.
- D. Fire-Resistance Ratings: Where a fire-resistance classification is indicated, provide access door assembly with panel door, frame, hinge, and latch from manufacturer listed in the UL "Building Materials Directory" for rating shown.
1. Provide UL Label on each fire-rated access door.

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- E. Local and State Regulatory Requirements: Submit forms or acceptance for proposed assemblies not conforming to specific UL firestop system numbers, or UL classified devices.
- F. Lead Free Compliance: All components associated with potable water systems (including, but not limited to, valves, end use devices/fixtures, pipe, pipe fittings, solder/flux, etc.) shall be "lead-free" in accordance with all local, state and federal codes, as well as NSF/ANSI 372 (NSF 61- G).

1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver joint sealer materials in original unopened containers or bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.
- B. Store and handle joint sealer materials in compliance with the manufacturers' recommendations to prevent their deterioration and damage.

1.7 PROJECT CONDITIONS

- A. Conditions Affecting Selective Demolition: The following project conditions apply:
 1. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
 2. Locate, identify, and protect mechanical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.
- B. Conditions Affecting Excavations: The following project conditions apply:
 1. Maintain and protect existing building services which transit the area affected by selective demolition.
 2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.
 3. Site Information: Subsurface conditions were investigated during the design of the Project. Reports of these investigations are available for information only; data in the reports are not intended as representations or warranties of accuracy or continuity of conditions. The Owner will not be responsible for interpretations or conclusions drawn from this information.
 4. Existing Utilities: Locate existing underground utilities in excavation areas prior to excavation. If utilities are indicated to remain, support and protect services during excavation operations.

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5. Remove existing underground utilities indicated to be removed.
 6. Uncharted or Incorrectly Charted Utilities: Contact utility owner immediately for instructions.
 7. Provide temporary utility services to affected areas. Provide minimum of 48-hour notice to Architect prior to utility interruption.
 8. Use of explosives is not permitted.
- C. Environmental Conditions: Apply joint sealers under temperature and humidity conditions within the limits permitted by the joint sealer manufacturer. Do not apply joint sealers to wet substrates.

1.8 SEQUENCE AND SCHEDULING

- A. Coordinate the shut-off and disconnection of utility services with the Owner and the utility company.
- B. Notify the Architect at least five (5) days prior to commencing demolition operations.
- C. Perform demolition in phases as indicated.

PART 2 - PRODUCTS

2.1 MECHANICAL EQUIPMENT NAMEPLATE DATA

- A. Nameplate: For each piece of power operated mechanical equipment provide a permanent operational data nameplate indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

2.2 FIRESTOPPING

- A. All penetrations through fire barriers shall be firestopped with an approved material that is capable of maintaining the fire resistance rating of the barrier. All firestop sealants shall conform to ASTM E 814, ASTM E 119, UL 1479, UL 2079 CAN/ULC S115, and CAN/ULC S101.
- B. Firestop material shall be latex based, intumescent caulk intended for use for all thru-penetrations with piping, cable trays, conduit, and cables.
- C. When exposed to high temperatures or fires, the caulk shall expand in volume to quickly close off voids left by melting or burning construction materials. Caulk shall be applied by a standard caulk gun and remain flexible after curing.
- D. Acceptable products shall be limited to Johns Manville "Firetemp-C1;" Hilti "FS-One;" or 3M "CP25WB+." Coordinate with General Contractor such that a single

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manufacturer/product is utilized throughout the project for all fire and smoke stopping materials.

2.3 SMOKE STOPPING

- A. All penetrations through smoke barriers, smoke partitions, or any other surface required to resist the passage of smoke shall be provided with a smoke stop sealant and/or system that has been independently tested to provide an acceptable smoke seal that will resist the passage of smoke. Smoke stop systems (including product and installation) shall conform to all applicable standards (including but not limited to ASTM, UL and NFPA), as well as all other local, state or federal requirements.
- B. Acceptable manufacturers shall be limited to the manufacturers that may provide firestopping materials/systems (see paragraph 2.02 of this section). Coordinate with the General Contractor such that a single manufacturer/product is utilized throughout the project for all fire and smoke stopping materials.

2.4 SOIL MATERIALS

- A. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, crushed slag, or natural or crushed sand.
- B. Drainage Fill: Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel, with 100 percent passing a 1-1/2-inch (40 mm) sieve, and not more than 5 percent passing a No. 4 sieve.
- C. Backfill and Fill Materials: Materials complying with ASTM D2487 soil classification groups GW, GP, GM, SM, SW, and SP; free of clay, rock, or gravel larger than 2 inches (150 mm) in any dimension; debris; waste; frozen materials; and vegetable and other deleterious matter.

2.5 MISCELLANEOUS METALS

- A. Steel plates, shapes, bars, and bar grating: ASTM A 36.
- B. Cold-Formed Steel Tubing: ASTM A 500.
- C. Hot-Rolled Steel Tubing: ASTM A 501.
- D. Steel Pipe: ASTM A 53, Schedule 40, welded.
- E. Non-shrink, Non-metallic Grout: Premixed, factory-packaged, non-staining, non-corrosive, non-gaseous grout, recommended for interior and exterior applications.
- F. Fasteners: Zinc-coated, type, grade, and class as required.

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2.6 MISCELLANEOUS LUMBER

- A. Framing Materials: Standard Grade, light-framing-size lumber of any species. Number 3 Common or Standard Grade boards complying with WCLIB or AWPA rules, or Number 3 boards complying with SPIB rules. Lumber shall be preservative treated in accordance with AWPB LP-2, and kiln dried to a moisture content of not more than 19 percent.
- B. Construction Panels: Plywood panels; APA C-D PLUGGED INT, with exterior glue; thickness as indicated, or if not indicated, not less than 15/32 inches (12 mm).

2.7 JOINT SEALERS

- A. General: Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.
- B. Colors: As selected by the Architect from manufacturer's standard colors.
- C. Elastomeric Joint Sealers: Provide the following types:
 1. One-part, nonacid-curing, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for masonry, glass, aluminum, and other substrates recommended by the sealant manufacturer.
 2. One-part, mildew-resistant, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for glass, aluminum, and nonporous joint substrates; formulated with fungicide; intended for sealing interior joints with non-porous substrates; and subject to in-service exposure to conditions of high humidity and temperature extremes.
- D. Acrylic-Emulsion Sealants: One-part, non-sag, mildew-resistant, paintable complying with ASTM C 834 recommended for exposed applications on interior and protected exterior locations involving joint movement of not more than plus or minus 5 percent.
- E. Fire-Resistant Joint Sealers: Two-part, foamed-in-place, silicone sealant formulated for use in through-penetration fire-stopping around cables, conduit, pipes through fire rated walls and floors. Sealants and accessories shall have fire resistance ratings indicated, as established by testing identical assemblies in accordance with ASTM E 814, by Underwriters' Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

2.8 ACCESS DOORS

- A. Steel Access Doors and Frames: Factory-fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded steel, with welds ground smooth and flush with adjacent surfaces.
- B. Frames: 16-gage (1.6 mm) steel, with a 1-inch (25 mm) wide exposed perimeter flange

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for units installed in unit masonry, pre-cast, or cast-in-place concrete, ceramic tile, or wood paneling.

1. For Installation in Masonry, Concrete, Ceramic Tile, or Wood Paneling: 1-inch (25 mm) wide exposed perimeter flange and adjustable metal masonry anchors.
 2. For Gypsum Wallboard or Plaster: Perforated flanges with wallboard bead.
 3. For Full-Bed Plaster Applications: Galvanized expanded metal lath and exposed casing bead, welded to perimeter of frame.
- C. Flush Panel Doors: 14-gage (2 mm) sheet steel, with concealed spring hinges or concealed continuous piano hinge set to open 175 degrees (3.05 Radians); factory-applied prime paint.
1. Fire-Rated Units: Insulated flush panel doors, with continuous piano hinge and self-closing mechanism.
- D. Locking Devices: Flush, screwdriver-operated cam locks.

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 installation and application of joint sealers and access panels. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 FIRESTOP INSTALLATION

- A. Install penetration seal materials in accordance with printed instructions of the UL Fire Resistance Directory and in accordance with manufacturer's instruction.
- B. Seal holes or voids made by penetrations to ensure an effective smoke barrier.
- C. Where floor openings without penetrating items are more than four inches (100 mm) in width and subject to traffic or loading, install firestopping materials capable of supporting same loading as floor.
- D. Protect materials from damage on surface subject to traffic.
- E. Place firestopping in annular space around fire dampers before installation of damper's anchoring flanges which are installed in accordance with fire damper manufacturer's recommendations.
- F. Where large openings are created in walls or floors to permit installation of pipes, cable tray, bus duct or other items, close unused portions of opening with firestopping material tested for the application.

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- G. Install smoke stopping as specified for firestopping.
- H. Where rated walls are constructed with horizontally continuous air space, double width masonry, or double stud frame construction, provide vertical, 12 inch (300 mm) wide fiber dams for full thickness and height of air cavity at maximum 15 foot (4500 mm) intervals.

3.3 PREPARATION FOR JOINT SEALERS

- A. Surface Cleaning for Joint Sealers: Clean surfaces of joints immediately before applying joint sealers to comply with recommendations of joint sealer manufacturer.
- B. Apply joint sealer primer to substrates as recommended by joint sealer manufacturer. Protect adjacent areas from spillage and migration of primers, using masking tape. Remove tape immediately after tooling without disturbing joint seal.

3.4 SELECTIVE DEMOLITION

- A. General: Demolish, remove, demount, and disconnect abandoned mechanical materials and equipment indicated to be removed and not indicated to be salvaged or saved.
- B. Materials and Equipment to be Salvaged: Remove, demount, and disconnect existing mechanical materials and equipment indicated to be removed and salvaged, and deliver materials and equipment to the location designated for storage.
- C. Disposal and Cleanup: Remove from the site and legally dispose of demolished materials and equipment not indicated to be salvaged.
- D. Mechanical Materials and Equipment: Demolish, remove, demount, and disconnect the following items:
 1. Inactive and obsolete piping, fittings and specialties, equipment, controls, fixtures, and insulation.
 2. Piping and ducts embedded in floors, walls, and ceilings may remain if such materials do not interfere with new installations. Remove materials above accessible ceilings. Drain and cap piping and ducts that are allowed to remain.
 3. Perform cutting and patching required for demolition in accordance with Division-01 Section "Cutting and Patching."

3.5 EXCAVATION

- A. Slope sides of excavations to comply with local codes and ordinances. Shore and brace as required for stability of excavation.
- B. Shoring and Bracing: Establish requirements for trench shoring and bracing to comply with local codes and authorities. Maintain shoring and bracing in excavations regardless

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of time period excavations will be open.

1. Remove shoring and bracing when no longer required. Where sheeting is allowed to remain, cut top of sheeting at an elevation of 30 inches (750 mm) below finished grade elevation.
- C. Install sediment and erosion control measures in accordance with local codes and ordinances.
- D. Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.
 1. Do not allow water to accumulate in excavations. Remove water to prevent softening of bearing materials. Provide and maintain dewatering system components necessary to convey water away from excavations.
 2. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey surface water to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.
- E. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade and shape stockpiles for proper drainage.
 1. Locate and retain soil materials away from edge of excavations. Do not store within drip-line of trees indicated to remain.
 2. Remove and legally dispose of excess excavated materials and materials not acceptable for use as backfill or fill.
- F. Excavation for Underground Tanks, Basins, and Mechanical Structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot (30 mm); plus a sufficient distance to permit placing and removal of concrete formwork, installation of services, other construction, and for inspection.
 1. Excavate by hand, areas within drip-line of large trees. Protect the root system from damage and dry-out. Maintain moist conditions for root system and cover exposed roots with burlap. Paint root cuts of 1 inch (25 mm) in diameter and larger with emulsified asphalt tree paint.
 2. Take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed.
- G. Trenching: Excavate trenches for mechanical installations as follows:
 1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches (150 to 225 mm) clearance on both sides of pipe and equipment.
 2. Excavate trenches to depth indicated or required for piping to establish indicated slope and invert elevations. Beyond building perimeter, excavate trenches to an elevation below frost line.

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3. Limit the length of open trench to that in which pipe can be installed, tested, and the trench backfilled within the same day.
 4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of pipe. Provide a minimum of 6 inches (150 mm) of stone or gravel cushion between rock bearing surface and pipe.
 5. Excavate trenches for piping and equipment with bottoms of trench to accurate elevations for support of pipe and equipment on undisturbed soil.
 6. For pipes or equipment 6 inches (150 mm) or larger in nominal size, shape bottom of trench to fit bottom 1/4 of the circumference. Fill unevenness with tamped sand backfill. At each pipe joint over-excavate to relieve the bell or pipe joint of the pipe of loads, and to ensure continuous bearing of the pipe barrel on the bearing surface.
- H. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35 degrees F (2 degrees C).
- I. Backfilling and Filling: Place soil materials in layers to required subgrade elevations for each area classification listed below, using materials specified in Part 2 of this Section.
1. Under walks and pavements, use a combination of subbase materials and excavated or borrowed materials.
 2. Under building slabs, use drainage fill materials.
 3. Under piping and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation.
 4. For piping less than 30 inches (750 mm) below surface of roadways, provide 4-inch (100 mm) thick concrete base slab support. After installation and testing of piping, provide a 4-inch (100 mm) thick concrete encasement (sides and top) prior to backfilling and placement of roadway subbase.
 5. In other areas, use excavated or borrowed materials.
- J. Backfill excavations as promptly as work permits, but not until completion of the following:
1. Inspection, testing, approval, and locations of underground utilities have been recorded.
 2. Removal of concrete formwork.
 3. Removal of shoring and bracing, and backfilling of voids.
 4. Removal of trash and debris.
- K. Placement and Compaction: Place backfill and fill materials in layers of not more than 8 inches (200 mm) in loose depth for material compacted by heavy equipment, and not

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- more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.
- L. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification specified below. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
 - M. Place backfill and fill materials evenly adjacent to structures, piping, and equipment to required elevations. Prevent displacement of piping and equipment by carrying material uniformly around them approximately to same elevation in each lift.
 - N. Compaction: Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below.
 - 1. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture-density relationship (cohesive soils), determined in accordance with ASTM D 1557 and not less than the following percentages of relative density, determined in accordance with ASTM D 2049, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).
 - 2. Areas Under Structures, Building Slabs and Steps, Pavements: Compact top 12 inches (300 mm) of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
 - 3. Areas Under Walkways: Compact top 6 inches (150 mm) of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
 - 4. Other Areas: Compact top 6 inches (150 mm) of subgrade and each layer of backfill or fill material to 85 percent maximum density for cohesive soils, and 90 percent relative density for cohesionless soils.
 - 5. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water. Apply water in minimum quantity necessary to achieve required moisture content and to prevent water appearing on surface during, or subsequent to, compaction operations.
 - O. Subsidence: Where subsidence occurs at mechanical installation excavations during the period twelve (12) months after Substantial Completion, remove surface treatment (i.e., pavement, lawn, or other finish), add backfill material, compact to specified conditions, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent areas.

3.6 ERECTION OF METAL SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

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- B. Field Welding: Comply with AWS "Structural Welding Code."

3.7 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.
- B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.8 APPLICATION OF JOINT SEALERS

- A. General: Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.
 - 1. Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
 - 2. Comply with recommendations of ASTM C 790 for use of acrylic emulsion joint sealants.
- B. Tooling: Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

3.9 INSTALLATION OF ACCESS DOORS

- A. Provide access doors (minimum 18" x 18") as required to provide maintainable access to all mechanical equipment including, but not limited to, valves, etc.
- B. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
- C. Adjust hardware and panels after installation for proper operation.

END OF SECTION 220500

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SECTION 220510 - PLUMBING RELATED WORK

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of mechanical related work required by this section is indicated on drawings and/or specified in other Division-22 sections.
- B. Types of mechanical related work specified in this section include the following:
 - 1. Access to Mechanical Work:
 - a. Access doors in floors.
 - b. Removable cover plates in floors.
 - 2. Excavating for Mechanical Work:
 - a. Underground mechanical utilities and services.
 - b. Drainage and distribution fields.
 - 3. Concrete for Mechanical Work:
 - a. Lean concrete backfill to support mechanical work.
 - b. Encasement of mechanical work.
 - c. Underground structural concrete to accommodate mechanical work.
 - d. Basins and curbs for mechanical equipment.
 - e. Mechanical equipment foundations and housekeeping pads.
 - f. Inertia bases for isolation of mechanical work.
 - g. Rough grouting in and around mechanical work.
 - h. Patching concrete cut to accommodate mechanical work.
 - 4. Painting of Mechanical Work:
 - a. Exposed concrete provided as part of mechanical work.
 - b. Exposed piping systems.
 - c. Exposed mechanical insulation.

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- d. Exposed mechanical equipment.
 - e. Color-coded work.
- C. Access door requirements associated with mechanical work and mechanically related electrical components are specified in this section.
- D. Quality control testing for concrete work is required as work of this section.

1.2 QUALITY ASSURANCE

- A. Access Units Fire-Resistance Ratings: Where fire-resistance rating is indicated for construction penetrated by access units, provide UL listed-and-labeled Class B units, except for units which are smaller than minimum size requiring ratings as recognized by governing authority.
- B. Concrete Work Codes and Standards: Comply with governing regulations and, where not otherwise indicated, comply with the following industry standards, whichever is the most stringent in its application to work in each instance:
 1. ACI 301 "Specifications for Structural Concrete for Buildings".
 2. ACI 311 "Recommended Practice for Concrete Inspection".
 3. ACI 318 "Building Code Requirements for Reinforced Concrete".
 4. ACI 347 "Recommended Practice for Concrete Formwork".
 5. ACI 304 "Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete".
 6. Concrete Reinforcing Steel Institute, "Manual of Standard Practice".
- C. Federal Specifications, Painting Work: In general and where applicable, comply with indicated Federal Specifications for paint quality, and use only paint from original containers which bear manufacturer's labels indicating compliance with required Federal Specifications.

1.3 SUBMITTALS

- A. Product Data, Access Units: Submit manufacturer's technical data and installation instructions for each type of access door assembly, including setting drawings, templates, instructions and directions for installation of anchorage devices.
- B. Shop Drawings, Mechanical Concrete Work: Submit shop drawings for structural type concrete work (tanks, vaults, basins, foundations and other supports), showing dimensions of formed shapes of concrete; bending, placement, sizes and spacing of reinforcing steel; location of anchors, isolation units, hangers and similar devices to be integrated with concrete work; and piping penetrations, access openings, inlets and other

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- accessories and work to be accommodated by concrete work.
- C. Manufacturer's Data, Mechanical Concrete Work: Submit data on products, including cements, special aggregates, form-coating compound, admixtures, moisture barriers, waterstops, expansion joint fillers, sealants, and concrete curing products. Provide manufacturer's certification where indicated.
 - D. Laboratory Test Reports, Mechanical Concrete Work: Submit laboratory test reports for concrete work materials, and for tested samples of placed concrete (where required as work of this section).
 - E. Mixing Tickets, Mechanical Concrete Work: Submit ticket for each batch of mixed concrete used in work, indicating project identification, location where placed, date, mixing time, mix type, amount of water introduced, amount of concrete placed, and other significant or unusual data.
 - F. Manufacturer's Data, Paint for Mechanical Work: Submit manufacturer's technical information, including analysis of ingredients and application instructions for products used in painting work.
 - G. Samples, Paint for Mechanical Work: Submit 12" x 12" (300 mm x 300 mm) color samples of each required finish paint color (except black and white); prepared on 1/8" (3 mm) tempered hardboard, on smooth face where application is for smooth surfaces and on texture face for textured surface applications. Use actual paint materials to be applied, and label each sample to show materials and coats applied.

1.4 PROJECT CONDITIONS

- A. Existing Utilities: Locate and protect existing utilities and other underground work in manner which will ensure that no damage or service interruption will result from excavating and backfilling.
- B. Protect property from damage which might result from excavating and backfilling.
- C. Protect persons from injury at excavations, by barricades, warnings and illumination.
- D. Coordinate excavations with weather conditions, to minimize possibility of washouts, settlements and other damages and hazards.
- E. Provide temporary covering or enclosure and temporary heat as necessary to protect bottoms of excavations from freezing and frost action. Do not install mechanical work on frozen excavation bases or subbases.
- F. Environmental Conditions, Painting Work: Comply with governing regulations concerning use of and conditions for application of paint. Comply with manufacturer's recommendations and instructions. Do not apply paint in unfavorable conditions of temperature, moisture (including humidity) or ambient contamination (dust and other pollutants).

PART 2 - PRODUCTS

2.1 ACCESS TO MECHANICAL WORK

- A. Access Doors - General: Where floors must be penetrated for access to mechanical work, provide types of access doors indicated, including floor doors if any. Furnish sizes indicated or, where not otherwise indicated, furnish adequate size for intended and necessary access. Furnish manufacturer's complete units, of type recommended for application in indicated substrate construction, in each case, complete with anchorages and hardware.
- B. Removable Access Plates:
 - 1. General: Where valves, control devices, cleanouts and similar elements of mechanical work are located within or behind wall, ceiling or floor construction or finishes, or below grade, and are not (cannot be), provided with integral removable access plates as specified in other Division-22 sections, provide removable access plates of types and sizes needed for access requirements, as indicated. Provide manufacturer's complete unit with anchorages, fasteners and standard factory-applied finishes.
 - 2. Wall/Ceiling Unit Construction: Except as otherwise indicated, and where adaptable to substrate, provide manufacturer's standard frameless round formed stainless steel or chrome-plated brass low profile plate cover, with single exposed flush screw anchor, with bright polished finish.
 - 3. Painted Finish: Where substrate is indicated for painted finish, provide steel units with prime-coat paint finish.
 - 4. Floor Unit Construction: Except as otherwise indicated, provide manufacturer's standard round cast-iron units, with frame or body designed for casting flush in concrete; with removable plate secured with bronze screws, and surfaced with non-slip cast pattern; natural mill finish.
 - a. Sleeve-Type: Where required floor opening or hand hole extends through thickness of cast floor slab, provide unit body of same depth as slab thickness, to act as form for casting opening.
 - b. Square Units: Where square units are indicated, provide manufacturer's modular units of size which integrate as closely as possible with finish flooring unit sizes (if any).
 - c. Recessed Units: Where finish of floor is other than concrete, provide recessed-panel type construction, of type and recess depth recommended to receive insets of floor finish indicated.
 - d. Finish: Provide recessed units with exposed metal (exposed after inset has been installed) of nickel bronze, manufacturer's standard finish. Provide matching fasteners.

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5. Units Set at Grade: Except as otherwise indicated, provide manufacturer's standard round or square cast-iron units, complete cast-iron pipe extension to protect mechanical element being accessed; designed to be set slightly above finish grade, and to be either supported by compacted soil or to be encased in concrete; secure plate to body with bronze screws; natural mill finish on plate and body.

2.2 EXCAVATING FOR MECHANICAL WORK

- A. Subbase Material: Provide graded mixture of gravel, sand, crushed stone or crushed slag.
 1. Finely-Graded Subbase Material: Well graded sand, gravel, crushed stone or crushed slag, with 100% passing 3/8" (10 mm) sieve.
- B. Backfill Material: Soil material suitable for compacting to required densities, and complying with AASHO Designation M145, Group A-1, A-2-4, A-2-5 or A-3.
- C. Drainage Fill Material: Washed and uniformly graded gravel, crushed stone or crushed slag, with 100% passing 1-1/2" (40 mm) sieve and not more than 5% passing No. 4 sieve.

2.3 MATERIALS OF CONCRETE WORK

- A. Forms for Exposed Concrete: Plywood, smooth metal or other smooth panel type material; sized for minimum joint exposure, and reinforced to prevent visible deflections resulting from pressure of placed concrete; sufficiently heavy for construction to prevent leakage which would be harmful to either structural or visual quality of concrete.
 1. Plywood "BB (Concrete Form) Plywood", Class I, Exterior Grade, mill-oiled and edge sealed.
- B. Forms for Unexposed Concrete: Smooth lumber, plywood or other easy-release material; reinforced to prevent excessive deflection or the possibility of failure during placement of concrete; sufficiently heavy for construction to prevent leakage which would be harmful to structural quality of concrete.
- C. Form Ties: For exposed concrete surfaces, provide snap-off type ties designed to snap off 1-1/2" (40 mm) below surface.
- D. Exposed-Corner Chamfer Strips: Provide wood, metal, plastic or rubber chamfer strips in forms at exposed external corners of concrete work.
- E. Form-Coating Compound: Commercially formulated compound which will prevent bond of concrete to forms. Provide compound recommended by manufacturer for application indicated, and which will not stain concrete or interfere with moisture curing of concrete or subsequent painting of exposed surfaces.
- F. Reinforcing Materials:

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1. Reinforcing Bars: Except as otherwise indicated, provide ANSI/ASTM A 615, deformed, Grade 40 for size numbers 3 through 18; ANSI/ASTM A 675, plain, Grade 60, for size number 2; sizes as shown.
2. Steel Wire: ANSI/ASTM A 82, plain, cold-drawn.
3. Welded Wire Fabric: ANSI/ASTM A 185; sizes and spacings of wires as shown; 6" x 6" (150 mm x 150 mm) x No. 10 x No. 10 where not otherwise indicated.
4. Reinforcement Supports: Provide supports for reinforcement including bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcing bars and welded wire fabric in place. Provide wire bar type supports complying with CRSI recommendations, unless otherwise indicated.
 - a. For on-grade work, provide supports with sand plates or horizontal runners.
 - b. At exposed surfaces, provide supports with legs that are stainless steel protected (CRSI, Class 2), or plastic protected (CRSI, Class 1).

G. Concrete Materials:

1. Portland Cement: ANSI/ASTM C 150, Type I, except as otherwise indicated.
2. Aggregates: ANSI/ASTM C 33, except as otherwise indicated.
 - a. Local aggregates not complying with ANSI/ASTM C 33, but which shown by special test or actual service to produce concrete of adequate strength and durability may be used.
 - b. For rough grouting, provide aggregate which is well graded and 100 percent passing through 3/8" (10 mm) sieve.
3. Water: Clean and free of substances harmful to concrete.
4. Air-Entraining Admixture: ANSI/ASTM C 260.
5. Water-Reducing Admixture: ANSI/ASTM C 494, Type A (normal range) and Type F (high-range, super plasticizer).
6. Set-Control Admixtures: ANSI/ASTM C 494, as follows:
 - a. Type B, Retarding.
 - b. Type C, Accelerating.
 - c. Type D, Water-reducing and Retarding.
 - d. Type E, Water-reducing and Accelerating.
 - e. Type G, High-Range Water-Reducing and Retarding (Super-plasticizer).
7. Calcium Chloride: Use not permitted.

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2.4 DESIGN AND PROPORTIONING OF MIXES

- A. General: Design mechanical work concrete as follows, for each 28-day compressive strength class:
 1. 4000 psi (27580 kPa) Class: 565 lbs. of cement per cu. yd. (335 kg/m³) (6.0 sacks), and 0.35 water/cement ratio.
 2. 3000 psi (20685 kPa) Class: 500 lbs. of cement per cu. yd. (296 kg/m³) (5.25 sacks), 0.46 water/cement ratio.
 3. 2500 psi (17238 kPa) Class: 450 lbs. of cement per cu. yd. (268 kg/m³) (4.75 sacks), and 0.54 water/cement ratio.
 4. Backfill Class (Lean Concrete): 375 lbs. of cement per cu. yd., (223 kg/m³) (4.0 sacks), and 0.60 water/cement ratio.
 5. Rough Grouting Class: 565 lbs. of cement per cu. yd. (335 kg/m³) (6.0 sacks), and 0.60 water/cement ratio.
- B. Admixtures: Except as otherwise indicated, use is at Contractor's option. Comply in each instance with admixture manufacturer's recommendations and suggested limitations for required quality of concrete. Use water-reducing admixture (normal or high-range in all concrete).
- C. Air Entrainment: Comply with the following limitations for resulting air entrainment:
 1. Concrete Above Grade: Not less than 2%, nor more than 4%.
 2. Concrete Below Grade: Not less than 2% nor more than 4%, except up to 6% where maximum aggregate size must be 3/4" (20 mm) or less.
 3. Rough Grout Concrete: Not less than 4%, nor more than 8%.
 4. Backfill Concrete: Not more than 7%.
- D. Slump Limitations: Limit water content in design mixes to produce the following slumps at point of placement (but do not exceed specified water/cement ratios). Concrete containing high-range water-reducing admixture may have slump limit up to 8" (200 mm).
 1. Reinforced Structural Concrete: For concrete which is reinforced (with more than shrinkage crack protection), or in strength class of 3000 psi (20685 kPa) and above, limit slump to range of 1" to 3" (25 mm to 75 mm).
 2. Plain Concrete: For concrete which is not reinforced or reinforced only for shrinkage crack protection, and in strength class below 3000 psi (20685 kPa), limit slump to range of 2" to 5" (50 mm to 125 mm).
 3. Rough Grout Concrete: Limit slump to range of 3" to 7" (75 mm to 175 mm).
 4. Backfill Concrete: Limit slump to 5" (125 mm).

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- E. Mix for Patching: Where mechanical work requires patching of exposed concrete work which has been cut to accommodate mechanical work, provide concrete patching mix which is identical with mix of work being patched (same cement, aggregates, admixtures and proportioning).

2.5 CONCRETE MIXING

- A. Job-Site Mixing: Mix materials for concrete in drum-type batch machine mixer. For mixers of 1.0 cu. yd. (.84 m³), or smaller capacity, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after all ingredients are in mixer, before any part of batch is released. For mixers of capacity larger than 1.0 cu. yd. (.84 m³), increase mixing time by 15 seconds for each additional cu. yd., or fraction thereof.
1. Prepare and submit batch ticket for each batch discharged and used in work.
- B. Ready-Mix Concrete: Comply with requirements of ANSI/ASTM C 94, except as otherwise indicated.
1. Delete references for allowing additional water to be added to batch for material with insufficient slump. Addition of water to batch will not be permitted.
 2. During hot weather, or under conditions contributing to rapid setting of concrete, mix each load for shorter period of time than specified in ANSI/ASTM C 94. When air temperature is between 85 and 90 degrees F (29.4 and 32.2 degrees C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes, and when air temperature is above 90 degrees F (32.2 degrees C), reduce mixing and delivery time to 60 minutes.

2.6 GENERAL PAINTING PRODUCT REQUIREMENTS

- A. Pigments: Provide paint with pure, non-fading pigments, recognized to be safe, durable and environmentally acceptable, and containing not more than 0.5 percent lead (by weight in total dry film).
- B. Vehicles and Thinners: Comply with governing regulations and recognized safe practices in handling, use and drying of paint vehicles and thinners. Compatibility of paint products is the Contractor's exclusive responsibility. Select paint products to ensure freedom from problems relating to vehicles and thinners of type and within limits recommended by paint manufacturer.
- C. Undercoat Paints: Use paint produced by same manufacturer as paint to be used for finish coats.
- D. Colors: Provide colors as indicated or established by the Owner by color schedule or by other indication or, where not otherwise indicated, as selected by the Owner from manufacturer's standard (non-premium cost) colors available for type of paint to be provided in each case.
- E. Color-Coded Finishes: For finishes indicated to be color-coded for identification, provide

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paint complying with the color requirements of ANSI A13.1 "Scheme for the Identification of Piping Systems", except where another specific color requirement is indicated.

- F. "Paint": As used herein means coating system materials, including primers, emulsions, enamels, sealers, fillers and other applied materials whether used as prime, intermediate or finish coats.
- G. Standards: In the following designated paint systems (example: "IPS-22") the descriptions similar to "... (TT-P-55, Type II)..." refer to Federal Specifications of that number, and indicate required compliance with that publication as minimum standard of quality for paint product as named. Product of recognized higher quality can be used, provided either label indicates compliance with required standard, or manufacturer submits proof and certification that product meets or exceeds standard in every significant measure of quality.
- H. Optional Systems: Where more than one paint system is designed for particular substrate, selection is Contractor's option except where distinct paint system is shown or scheduled for particular portion or area of that substrate.

2.7 INTERIOR PAINT SYSTEMS

A. Concrete:

- 1. IPS-1: 1st Coat - Interior latex emulsion (TT-P-29).
 2nd Coat - Interior latex emulsion (TT-P-29).
 2nd Coat - Interior alkyd emulsion, odorless (TT-P-30).
- 2. IPS-2: 1st Coat - Interior latex emulsion (TT-P-29).
 2nd Coat - Interior enamel undercoat (TT-E-543).
 3rd Coat - Interior enamel, semi-gloss (TT-E-509).
 Not less than 3.5 mils total dry-film thickness.
- 3. IPS-3: 1st Coat - Acrylic emulsion (TT-P-19).
 2nd Coat - Acrylic emulsion (TT-P-19).
- 4. IPS-4: 1st Coat - Interior latex emulsion (TT-P-29).
 2nd Coat - Polyester epoxy (TT-C-5451).
 3rd Coat - Polyester epoxy (TT-C-545).
 Not less than 4.0 mils dry-film thickness

B. Cement:

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1. IPS-9: 1st Coat - Interior latex emulsion (TT-P-29).

 2nd Coat - Interior latex emulsion (TT-P-29).
- C. Ferrous Metal:
 1. IPS-19: 1st Coat - Red lead primer (TT-P-86).

 2nd Coat - Interior latex emulsion (TT-P-29).

 3rd Coat - Interior latex emulsion (TT-P-29).

 First coat not required on items that are shop primed.

 Not less than 2.5 mils dry-film thickness.
 2. IPS-20: 1st Coat - Red lead primer (TT-P-86).

 2nd Coat - Enamel undercoat (TT-E-543).

 3rd Coat - Semi-gloss enamel (TT-E-509).

 First coat not required on items that are shop primed.

 Not less than 2.5 mils dry-film thickness.
 3. IPS-21: 1st Coat - Red lead primer (TT-P-86).

 2nd Coat - Enamel undercoat (TT-E-543).

 3rd Coat - Gloss enamel (TT-E-506).

 First coat not required on items that are shop primed.

 Not less than 2.5 mils dry-film thickness.
- D. Zinc-Coated Metal:
 1. IPS-22: 1st Coat - Zinc dust-zinc oxide primer (TT-P-641).

 2nd Coat - Interior latex emulsion (TT-P-29).

 3rd Coat - Interior latex emulsion (TT-P-29).

 Not less than 2.5 mils dry-film thickness.
 2. IPS-23: 1st Coat - Zinc dust-zinc oxide primer (TT-P-641).

 2nd Coat - Enamel undercoat (TT-E-543).

 3rd Coat - Semi-gloss enamel (TT-E-509).

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Not less than 2.5 mils dry-film thickness.

3. IPS-24: 1st Coat - Zinc dust-zinc oxide primer (TT-641).

2nd Coat - Enamel undercoat (TT-E-543).

3rd Coat - Gloss Enamel (TT-E-506).

Not less than 2.5 mils dry-film thickness.

E. Fabric Covering on Insulation:

1. IPS-33: 1st (Size) Coat - Interior latex emulsion (TT-P-29).

2nd Coat - Interior latex emulsion (TT-P-29).

Add fungicidal agent to render fabric mildew-proof.

PART 3 - EXECUTION

3.1 ACCESS TO MECHANICAL WORK

- A. Comply with manufacturer's instructions for installation of floor doors, and removable access plates.
- B. Set frames accurately in position and securely attach to supports with face panels plumb or level in relation to adjacent finish surfaces.
- C. Adjust hardware and panels after installation for proper operation.
- D. Remove or replace panels or frames which are warped, bowed, or otherwise damaged.

3.2 EXCAVATING FOR MECHANICAL WORK

- A. General: Do not excavate for mechanical work until work is ready to proceed without delay, so that total time lapse from excavation to completion of backfilling will be minimum.
- B. Excavate with vertical sided excavations to greatest extent possible, except where otherwise indicated. Where necessary, provide sheeting and cross-bracing to sustain sides of excavations. Remove sheeting and cross-bracing during backfilling wherever such removal would not endanger work or other property. Where not removed, cut sheeting off at sufficient distance below finished grade to not interfere with other work.
- C. Width: Excavate for piping with 6" to 9" (150 mm to 225 mm) clearance on both sides of pipe, except where otherwise shown or required for proper installation of pipe joints, fittings, valves and other work. Excavate for other mechanical work to provide minimum practical but adequate working clearances.

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- D. Depth for Direct Support: For work to be supported directly on undisturbed soil, do not excavate beyond indicated depths, and hand-excavate bottom cut to accurate elevations. Except as otherwise indicated, support the following work on undisturbed soil at bottom of the excavations:
 - 1. Piping of 5" (125 mm) and less pipe/tube size.
 - 2. Cast-in-place concrete.
- E. Depth for Subbase Support: For large piping (6" pipe size and larger) (150 mm pipe size and larger) tanks, and where indicated for other mechanical work, excavate for installation of subbase material in depth indicated or, if not otherwise indicated, 6" (150 mm) below bottom of work to be supported.
- F. Depth for Unsatisfactory Soil Conditions: Where directed (because of unsatisfactory soil condition at bottom of indicated excavation), excavate additional depth as directed to reach satisfactory soil bearing condition. Backfill with subbase material, compacted as directed, to indicated excavation depth.
- G. Depth for Exterior Piping: Except as otherwise indicated, excavate for exterior water-bearing piping (water, steam condensate, drainage) so that top of piping will not be less than 2'- 6" (600 mm-150 mm) vertical distance below finished grade.
- H. Excavate near large trees (within drip line) by hand, and protect root system from damage or dryout to greatest extent possible. Maintain moist condition for root system and cover exposed roots with burlap. Paint root cuts of 1" (25 mm) diameter and larger with asphaltic tree paint.
- I. Store excavated material (temporarily) near excavation, in manner which will not interfere with or damage excavation or other work. Do not store under trees (within drip line).
 - 1. Retain excavated material which complies with requirements for backfill material.
 - 2. Dispose of excavated material which is either in excess of quantity needed for backfilling or does not comply with requirements for backfill material.
 - a. Move unused material to another location on Owner's property, at or adjacent to project site, and dispose of as directed by the Owner.
 - b. Remove unused material from project site, and dispose of in lawful manner.

3.3 DEWATERING

- A. Maintain dry excavations for mechanical work, by removing water. Protect excavations from inflow of surface water. Pump minor inflow of ground water from excavations; protect excavations from major inflow of ground water, by installing temporary sheeting and waterproofing. Provide adequate barriers which will protect other excavations and below-grade property from being damaged by water, sediment or erosion from or through mechanical work excavations.

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1. Install and operate well-point dewatering system to maintain ground water at level approximately 2'- 0" (600 mm - 0 mm) below mechanical work excavations, until backfilling is completed.

3.4 BASE PREPARATION

- A. Subbase Installation: Where indicated, install subbase material to receive mechanical work, and compact by tamping to form firm base for work. For piping, horizontal cylindrical tanks, and similar work, shape subbase to fit shape of bottom 90 degree of cylinder, for uniform continuous support.
 1. Provide finely-graded subbase material for wrapped, coated, and plastic pipe and tanks.
- B. Shape subbases and bottoms of excavations with recesses to receive pipe bells, flanged connections, valves and similar enlargements in piping systems.
- C. Concrete Encasement: Where piping under roadways is less than 2'- 6" (600 mm-150 mm) below surface of roadway, provide 4" (100 mm) base slab of concrete to support piping. After piping is installed and tested, provide 4" (100 mm) thick encasement (sides and top) of concrete before backfilling. Provide Class 2500 concrete for encasement and slab.
- D. Previous Excavations: Where piping crosses over area more than 5'- 0" (1.5 m-0 mm) wide which has been previously excavated to greater depth than required for piping installation, provide suitable subsidence-proof support for piping. Comply with details shown or, where not otherwise shown, provide one of the following support systems:
 1. Excavate to undisturbed soil, in width equal to pipe diameter plus 2'- 0" (600 mm-0 mm). Install 8" (200 mm) courses of subbase material, each compacted to 95% of maximum density, as required to fill excavation and support piping.
 2. Excavate to undisturbed soil, in width equal to pipe diameter plus 1'-0" (300 mm - 0 mm). Install lean concrete fill to required elevation for support of piping.

3.5 BACKFILLING

- A. Do not backfill until installed mechanical work has been tested and accepted, wherever testing is indicated.
- B. Install drainage fill where indicated, and tamp to uniform firm density.
- C. Backfill with finely-graded subbase material to 6" (150 mm) above wrapped, coated, and plastic piping and tanks, and to centerline of other tanks.
- D. Condition backfill material by either drying or adding water uniformly, to whatever extent may be necessary to facilitate compaction to required densities. Do not backfill with frozen soil materials.

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- E. Backfill simultaneously on opposite sides of mechanical work, and compact simultaneously; do not dislocate work from installed positions.
- F. Backfill excavations in 8" (200 mm) high courses of backfill material, uniformly compacted to the following densities (% of maximum density, ASTM D 1557), using power-driven hand-operated compaction equipment.
 - 1. Lawn and Landscaped Areas: 85% for cohesive soils; 90% for cohesionless soils.
 - 2. Paved Areas, Other Than Roadways: 90% for cohesive soils; 95% for cohesionless soils.
 - 3. Roadways: 90% for cohesive soils; 95% for cohesionless soils.
- G. Backfill to elevations matching adjacent grades, at time of backfilling excavations for mechanical work.
- H. Compaction Tests: Where compaction tests indicate lower densities of backfill than specified, continue compaction (and re-excavation and backfilling where necessary) and provide additional testing as directed by the Owner. Allowable density tolerance is not more than one-test-out-of-5 falling more than 2 percentage points below specified density.

3.6 PERFORMANCE AND MAINTENANCE, EXCAVATION WORK

- A. Subsidence: Where subsidence is measurable or observable at mechanical work excavations during general project warranty period, remove surface (pavement, lawn or other finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.7 INSTALLATION OF CONCRETE WORK

- A. Formwork:
 - 1. General: Design, construct and maintain formwork to support vertical and lateral loads including pressure of cast-in-place concrete. Construct formwork so that formed concrete will be required size and shape and in required location. Construct with joints which will not leak cement paste. Form sides and bottoms of concrete work, except where clearly indicated to be cast directly in excavation or against other construction, or on grade or prepared subgrade. Design and construct forms for easy removal without damage to concrete and other work.
 - a. Install chamber strips at external corners of exposed concrete work.
 - b. Construct forms to retain equipment anchor bolts in accurate locations during placement of reinforcing steel and concrete. Use templates, if available by equipment manufacturers, to locate anchor bolts or, where not furnished, locate by accurate measure from certified setting diagrams.

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2. Form Coating: Coat concrete-contact surfaces of forms to be removed. Apply form-coating compound before reinforcement is placed. Apply in accordance with manufacturer's instructions and remove excess compound and spillage.
3. Cleaning and Tightening: Clean forms and adjacent surfaces to receive concrete just before concrete is placed. Retighten forms promptly during concrete placement where required to eliminate leakage of cement paste.

B. Placing Reinforcement:

1. General: Comply with requirements and recommendations of specified standards, including "Placing Reinforcing Bars" by CRSI. Place bars where indicated and support to prevent displacement during concrete placement, using appropriate reinforcement supports, properly spaced and wire tied to reinforcing bars.
 - a. Place reinforcement to obtain at least minimum recommended coverage for concrete protection. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.
 - b. Install welded wire fabric in as long lengths as practicable. Laps adjoining pieces at least one full mesh and lace splices with 16-gage (1.6 mm) wire. Offset end laps in adjacent widths to prevent continuous laps in either direction.
 - c. Clean reinforcement of loose rust and mill scale, earth, ice, and other materials which would reduce bond with concrete.

C. Placing Concrete:

1. Wet wooden forms which have been coated with compound, immediately before concrete, and remove excess water from forms.
2. Strength-Class Applications: Comply with compressive-strength classes shown on drawings for each unit of mechanical concrete work or, if not shown, comply with the following general application requirements.
 - a. Backfill: Provide backfill class (lean concrete).
 - b. Plain Concrete Encasement: Provide 2500 psi (17238 kPa) class.
 - c. Reinforced Concrete Encasement: Provide 3000 psi (20685 kPa) class.
 - d. Underground Structural Concrete: Provide 3000 psi (20685 kPa) class.
 - e. Tanks and Vaults: Provide 4000 psi (27580 kPa) class.
 - f. Block-Type Foundations: Where least dimension is not less than 0.2 x largest dimension, provide 3000 psi (20685 kPa) class.
 - g. Beam-Type Foundations: Where least dimension is less than 0.2 x largest dimension, provide 4000 psi (27580 kPa) class.

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- h. Miscellaneous Supported Work: Provide 3000 psi (206850 kPa) class for curbs, pads, inertia blocks and similar supported work.
 - i. Concrete Fill: Provide 2500 psi (17238 kPa) class for filling structural steel foundation frames and for filling similar large-volume units.
 - j. Concrete Grout: Provide rough grouting class for filling voids to be grouted which are too small to be filled effectively with 2500 psi (17238 kPa) class concrete.
 - k. Patching General Concrete Work: Match concrete being patched.
3. Deposit concrete continuously or in layers of thickness which will result in no concrete being placed on concrete which has hardened sufficiently to cause formation of seams or planes of weakness within section. If section cannot be placed continuously, provide construction joints. Deposit concrete as nearly as practicable in its final location, so as to avoid segregation due to rehandling or flowing.
 4. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand-spading, rodding or tamping. Use equipment and procedures complying with recommended practices of ACI 309; eliminate voids in work.
 5. Bring horizontal surfaces to correct level with straightedge and strike off. Use bull floats or darbies to smooth surface, free of humps and hollows.
 6. Cold Weather Placement: Comply with ACI 306. Do not use frozen materials or materials containing ice and snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials. When air temperature has fallen or is expected to fall below 40 degrees F (4.4 degrees C), heat water and aggregates uniformly before mixing, as required to obtain concrete mixture temperature of not less than 50 degrees F (10 degrees C), and not more than 80 degrees F (26.7 degrees C), at time of placement. Protect concrete work from physical damage and reduced strength resulting from frost, freezing actions, or low temperatures.
 7. Hot Weather Placement: Comply with ACI 305 when hot weather conditions could impair work.
 - a. Maintain concrete temperature below 90 degrees F (32.2 degrees C) at time of placement, by cooling ingredients. Mixing water may be chilled, or chopped ice may be used to control concrete temperature, provided water equivalent of ice is included in calculating compliance with water/cement ratio limitations. Cover reinforcing steel with water-soaked burlap as necessary to ensure that steel temperature will not exceed ambient air temperature immediately before embedment in concrete.
 8. Finishing Horizontal Surfaces: Float and trowel horizontal (top) surfaces to level, smooth, uniform textured, dense finish, where surface is to remain exposed or receive coating, membrane or other thin-set finish. Otherwise, leave struckoff surface undisturbed; except scratch surfaces which are to receive concrete or mortar topping or setting bed, by raking with a stiff broom.

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- a. Depress top of concrete backfill sufficiently so that supported work can be set in bed of mortar or sand as indicated.
 9. Curbs: Provide monolithic finish on interior curbs by stripping forms while concrete is still green and steel-troweling surfaces to hard, dense finish with corners, intersections and terminations slightly rounded and coved.
- D. Form Removal and Surface Repairs:
1. Form Removal: Remove forms as soon as concrete has set and gained sufficient strength to ensure that neither removal of forms nor stress introduced by removal of support contributed by forms will result in damage to concrete.
 - a. Retain forms on vertical surfaces of concrete for not less than three (3) days after concrete is placed.
 - b. Retain forms supporting horizontal and angular bottom surfaces of concrete for not less than fourteen (14) days after concrete is placed, except where indicated for longer periods of support.
 2. Unexposed Surfaces: Repair significantly damaged and honeycombed areas, and remove major projections and fins where forms have been removed.
 3. Exposed Surfaces: On formed surfaces which are to be exposed, including those to be coated or covered with membrane or other thin-set applied finish, repair and patch form-tie holes and damaged and honeycombed areas, filling voids with grout and completely removing fins and other projections.

3.8 CONCRETE CURING AND PROTECTION

- A. General:
1. Protect freshly placed concrete from drying and excessively cold and hot temperatures, and maintain in moist condition at relatively constant temperature for period of time necessary for hydration of cement, proper hardening, and achievement of strength requirements as specified.
 - a. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting, keep continuously moist for not less than seventy-two (72) hours.
 - b. Begin final curing procedures immediately following initial curing and before concrete has dried. Continue curing for at least seven (7) days and in accordance with ACI 301 procedures. Avoid rapid drying at end of final curing period.
 - c. Subgrade concrete backfill may be excluded from final curing procedures where adjoining subsoil is sufficiently moist to maintain concrete in moist condition.

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- B. Curing Method: Perform final curing for each area of concrete work by one of the following methods (at Contractor's option), as appropriate for location and accommodation of adjacent construction work which must continue:
1. Continuous water emersion or fog spraying.
 2. Covering with absorptive cover which is maintained in wet-to-fully saturated condition.
 3. Covering with moisture retaining cover, with sealed joints and maintained without holes or openings as non-breathing membrane.
 4. Coating with membrane-forming curing compound, applied in two (2) coats and maintained in effective condition for cure period (replaced if degraded by rain before reaching stable condition).
 - a. Do not use compound curing method where surface is to be painted, dampproofed, waterproofed, or covered with other finish requiring bond to concrete.
 - b. Do not use compound curing method where forms must be retained more than three (3) days.

3.9 MISCELLANEOUS CONCRETE WORK

- A. Concrete Grouting: Grout openings and recesses as indicated, in and around mechanical work and other work which penetrates or adjoins mechanical concrete work, using rough grouting class of concrete mix. Provide formwork where required, and tamp, screed and trowel surfaces. Cure grout as specified for concrete work.
- B. Refer to individual equipment sections of these specifications for fine-grouting of equipment base plates on foundations (usually with non-shrinking grout), and similar grouting requirements not defined herein as concrete work.

3.10 QUALITY CONTROL TESTING

- A. Engage testing laboratory to take samples, perform tests, and prepare and submit reports for concrete as it is placed.
1. Backfill Concrete: Quality control testing is not required for backfill concrete (lean concrete).

3.11 SURFACE PREPARATION FOR PAINTING

- A. General: Clean surfaces before applying paint products. Remove oil and grease prior to mechanical cleaning. Comply with paint products manufacturer's instructions for surface cleaning and preparation. Remove surface-applied accessories which are not to be painted, and reinstall after completion of painting. Protect non-removable items not to be

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- painted, by covering with paper or plastic material.
- B. Cementitious Surfaces: Remove efflorescence, chalk, dust, and glaze to ensure good bond of paint products. Clean concrete with muriatic acid (1 part diluted with 6 to 8 parts water) and flush with water, where necessary to ensure good paint bond. Perform appropriate tests to determine that both alkalinity and moisture content of concrete surfaces are below maximum allowable levels for painting, as recommended by paint manufacturer.
 - C. Ferrous Metal Surfaces: Remove mill scale and loose rust on surfaces which are not zinc-coated or shop/factory prime coated.
 - D. Clean shop-applied prime coats on metal surfaces, and repair (touch-up) prime coats wherever abraded or otherwise damaged, prior to application of paint system.
 - E. Zinc-Coated Surfaces: Clean with non-petroleum based solvent. Wash with copper sulfate solution and flush with water, unless surface has been pretreated, or unless treatment is not recommended by manufacturer of prime coat.

3.12 PAINT SYSTEM APPLICATION

- A. Mixing: Comply with manufacturer's recommendations for mixing or stirring paint products immediately before application.
- B. Application Limitations: Except as otherwise indicated, paint every accessible surface of each unit of work indicated to be painted, regardless of whether in location recognized as "concealed" or "exposed".
 - 1. Omit painting on surfaces located in service shafts and tunnels and above non-removable ceilings and in similar place where space is too limited or services are too congested to allow access for painting.
 - 2. Omit painting of insulated piping above removable ceilings, but apply paint system to uninsulated steel piping, exposed threads of galvanized piping, pipe hangers, and similar work.
 - 3. Omit painting on machined sliding surfaces and rotating shafts of equipment, and on nonferrous finished metals including chrome plate, stainless steel, special anodized aluminum, brass/bronze and copper, and on plastics and similar finished materials, except where specifically indicated to be color-coded by painting.
 - 4. Omit painting on required name plates, labels, identification tags, signs, markers, printed instructions, performance ratings, flow diagrams and similar text and graphics, located within the scope of work indicated to receive paint application.
 - 5. Omit specified prime coat of paint system for metal surfaces where surface has shop-applied prime coat of equivalent quality. Apply prime coat on other surfaces to be painted; comply with paint manufacturer's instructions for prime coating where not otherwise indicated. Apply additional prime coats where suction spots or unsealed areas appear.

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- C. General Application Requirements: Apply paint in accordance with manufacturer's directions. Use applicators and techniques best suited for substrate, for type of material being applied, and for ambient conditions. Apply additional coats when undercoats, stains or other conditions show through final coat of paint, until paint film is of uniform finish, color and appearance. Apply paint at edges, corners, joints, welds and exposed fasteners in manner which will ensure dry-film thickness equal to that of flat surfaces. Allow sufficient time between successive coats for proper drying (comply with manufacturer's drying instructions).
- D. Number of Coats: Number indicated is minimum number; apply as many coats as are necessary to comply with dry-film thickness requirements.
- E. Coating Thickness: Apply uniform coats to produce dry-film thickness indicated or, if not otherwise indicated, apply paint without thinning in application thickness recommended by manufacturer for each coat.
- F. Smooth Finishes: Except as otherwise indicated, apply paint in smooth finish without noticeable texture, cloudiness, spotting, holidays, laps, brush marks, runs, sags, ripples, ropiness and other surface imperfections.
- G. Textured Finishes: Where indicated, roll and redistribute paint of final coat to even texture. Match adjoining textured paint finishes if any, and roll to eliminate evidence of roller or lap marks and other unevenness and imperfections.
- H. Exterior Stacks: Paint the top 18" (450 mm) of stacks black, regardless of color selected for general painting of equipment and accessories on roof.

3.13 CLEAN-UP AND PROTECTION, PAINTING

- A. General Clean-Up: During progress of work, remove from site discarded paint materials, rubbish, cans and rags at end of each work day. Retain paint containers from application of coatings on particular unit or area of work, until average dry-film thickness has been calculated.
- B. Spattered Surfaces: Upon completion of painting work, clean paint-spattered surfaces. Remove spattered paint by proper methods of washing and scraping, using care not to scratch or otherwise damage finished surfaces.
- C. Protection: Protect work of other trades, whether to be painted or not, against damage by painting work. Correct damage by cleaning, repairing or replacing and repainting as directed. Provide "Wet Paint" signs as required to protect newly-painted finishes. Remove temporary protective wrappings installed for protection of work not to be painted, after completion of painting operations. At completion of work by other trades, touch-up and restore damaged or defaced painted surfaces.

END OF SECTION 220510

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SECTION 220513 - ELECTRICAL PROVISIONS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Types of work normally recognized as electrical, but provided as mechanical, specified or partially specified in this section, include but are not necessarily limited to the following:
 - 1. Motors for mechanical equipment.
 - 2. Wiring from motors to disconnect switches or junction boxes for motors of mechanical equipment, but only where specifically indicated to be furnished integrally with equipment.
 - 3. Wiring of field-mounted float control switches, flow control switches, and similar mechanical-electrical devices provided for mechanical systems, to equipment control panels.
- B. Refer to requirements of Division-26 sections.

1.2 QUALITY ASSURANCE

- A. Coordination with electrical work: wherever possible, match elements of electrical provisions of mechanical work with similar elements of electrical work specified in division-26 sections for electrical work of this section which is not otherwise specified.
- B. Standards: For electrical equipment and products, comply with applicable NEMA standards, and refer to NEMA standards for definitions of terminology herein. Comply with National Electrical Code (NFPA 70) for workmanship and installation requirements.

1.3 SUBMITTALS

- A. Listing, Motors of Mechanical Work: Concurrently, with submittal of mechanical products listing (Basic Mechanical and Division-01 requirements), submit separate listing showing rating, power characteristics, application (connected equipment), and general location of every motor to be provided with mechanical work. Submit updated information promptly when and if initial data is revised.
 - 1. Include in listing of motors, notations of whether motor starter is furnished or installed integrally with motor or equipment containing motor.

PART 2 - PRODUCTS

2.1 MOTORS

- A. Motor Characteristics: Except where more stringent requirements are indicated, and except where required item of mechanical equipment cannot be obtained with fully complying motor, comply with the following requirements for motors of mechanical work:
- B. Temperature Rating: Rated for 113 degrees F (40 degrees C) environment with maximum 122 degrees F (50 degrees C) temperature rise for continuous duty at full-load (Class B Insulation).
- C. Starting Capability: Provide each motor capable of making starts as frequently as indicated by automatic control system, and not less than five (5) starts per hour for manually controlled motors.
- D. Phases and Current Characteristics: Provide squirrel cage induction polyphase motors for 1/2 hp (.4 kW) and larger, and provide capacitor-start single-phase motors for 1/3 hp (.25 kW) and smaller, except 1/6 hp (.1 kW) and smaller may, at equipment manufacturer's option, be split-phase type. Coordinate current characteristics with power specified in Division-26 sections, and with individual equipment requirements specified in other Division-22 requirements. For 2-speed motors provide two (2) separate windings on polyphase motors. Do not purchase motors until power characteristics available at locations of motors have been confirmed, and until rotation directions have been confirmed.
- E. Service Factor: 1.15 for polyphase motors and 1.35 for single-phase motors.
- F. Motor Construction: Provide general purpose, continuous duty motors, Class F insulation, Design "B" except "C" where required for high starting torque.
 - 1. Bearings: Ball or roller bearings with inner and outer shaft seals, regreasable except permanently sealed where motor is normally inaccessible for regular maintenance. Where belt drives and other drives produce lateral or axial thrust in motor, provide bearings designed to resist thrust loading. Refer to individual sections of Division-22 for fractional-hp light-duty motors where sleeve-type bearings are permitted.
 - 2. Enclosure Type: Except as otherwise indicated, provide open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation, and provide guarded drip-proof motors where exposed to contact by employees or building occupants. Provide weather-protected Type I for outdoor use, Type II where not housed. Refer to individual sections of Division-22 for other enclosure requirements.
 - 3. Overload Protection: Provide built-in thermal overload protection and, where indicated, provide internal sensing device suitable for signaling and stopping motor at starter.
 - 4. Noise Rating: Provide industry standard "Quiet" rating on motors.

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5. Efficiency: For motors 1 horsepower (.7 kW) or higher, provide motors with minimum efficiencies as follows in accordance with IEEE Standard 112, Test Method B:

a. Open Motors (ODP)

	<u>MOTOR HP (KW)</u>	<u>MINIMUM EFFICIENCY *</u>		
		<u>1200 RPM</u>	<u>1800 RPM</u>	<u>3600 RPM</u>
	1 (.7)	82.5%	85.5%	77.0%
	1.5 (1.1)	86.5%	86.5%	84.0%
	2 (1.5)	87.5%	86.5%	85.5%
	3 (2.2)	88.5%	89.5%	85.5%
	5 (4)	89.5%	89.5%	86.5%
	7.5 (5.6)	90.2%	91.0%	88.5%
	10 (8)	91.7%	91.7%	89.5%

* Required Full Load Nominal Efficiency shall be in accordance with EISA 2007. Where efficiency listed above is higher than the EISA 2007 requirement, provide the higher efficiency indicated.

b. Enclosed Motors (TEFC)

	<u>MOTOR HP (KW)</u>	<u>MINIMUM EFFICIENCY *</u>		
		<u>1200 RPM</u>	<u>1800 RPM</u>	<u>3600 RPM</u>
	1 (.7)	82.5%	85.5%	77.0%
	1.5 (1.1)	87.5%	86.5%	84.0%
	2 (1.5)	88.5%	86.5%	85.5%
	3 (2.2)	89.5%	89.5%	86.5%
	5 (4)	89.5%	89.5%	88.5%
	7.5 (5.6)	91.0%	91.7%	89.5%
	10 (8)	91.0%	91.7%	90.2%

* Required Full Load Nominal Efficiency shall be in accordance with EISA 2007. Where efficiency listed above

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- is higher than the EISA 2007 requirement, provide the higher efficiency indicated.
- c. Where pump motors are used in conjunction with, or controlled by, a variable frequency drive (VFD), motors shall be suitable for VFD operation (inverter duty motors).
 - d. For motors less than 1 horsepower (.7 kW), provide motors with higher efficiency than "average standard industry motors," in accordance with IEEE Standard 112, test method B.
- G. Nameplate: Provide metal nameplate on each motor, indicating full identification of manufacturer, ratings, characteristics, construction, special feature and similar information.
- H. Motor Modifications: In cases where the equipment submitted requires additional motors and/or controls, circuiting and related equipment shall be provided as approved and in accordance with the National Electrical Code. All costs relative to these electrical changes shall be included under the Section in which the equipment is furnished and installed and shall be coordinated with the electrical work at no expense to the Owner.
- I. Power Factor: All motors one (1) horsepower and above shall have a minimum power factor of 0.90.
- J. All motors operated on variable frequency drives shall be equipped with a maintenance free, conductive microfiber, shaft grounding ring with a minimum of two (2) rows of circumferential microfibers to discharge electrical shaft currents within the motor and/or its bearings. Motors up to 100 HP shall be provided with a minimum of one (1) shaft grounding ring installed either on the drive end or non-drive end. Motors over 100 HP shall be provided with an insulated bearing on the non-drive end and a shaft grounding ring on the drive end of the motor. Grounding rings shall be provided and installed by the motor pump manufacturer or contractor and shall be installed in accordance with the manufacturer's recommendations.

2.2 MECHANICAL EQUIPMENT

- A. All mechanical equipment shall be approved and listed by Underwriters' Laboratories (UL) and shall bear nameplate indicating same.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install motors on motor mounting systems in accordance with motor manufacturer's instructions, securely anchored to resist torque, drive thrusts, and other external forces inherent in mechanical work. Secure sheaves and other drive units to motor shafts with keys and Allen set screws, except motors of 1/3 hp (.25 kW) and less may be secured with Allen set screws on flat surface of shaft. Unless otherwise indicated, set motor shafts

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- parallel with machine shafts.
- B. Deliver starters and wiring devices which have not been factory installed on equipment unit to electrical Installer for installation.
 - C. Install furnished under Division-26 starter panels and wiring devices at locations indicated, securely supported and anchored, and in accordance with manufacturer's installation instructions. Locate in accordance with National Electric Code for installation requirements.

END OF SECTION 220513

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SECTION 220514 - PIPE, TUBE AND FITTINGS FOR PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of pipes and pipe fittings required by this section is indicated on drawings and/or specified in other Division-22 sections.
- B. Types of pipes and pipe fittings specified in this section include the following:
 - 1. Steel Pipes
 - 2. Copper Tube
 - 3. Cast-Iron Pressure Pipes
 - 4. Cast-Iron Soil Pipes
 - 5. Plastic Pipes
 - 6. Foundation Drainage Tile and Pipes
 - 7. Miscellaneous Piping Materials/Products
- C. Pipes and pipe fittings furnished as part of factory-fabricated equipment are specified as part of the equipment assembly in other Division-22 sections.
- D. Refer to all Division-21 and -22 sections.

1.2 QUALITY ASSURANCE

- A. Codes and Standards:
 - 1. Welding: Qualify welding procedures, welders and operators in accordance with ASME B 3 1.1, or ASME B 31.9, as applicable, for shop and project site welding of piping work.
 - a. Certify welding of piping work using the Standard Procedure Specifications by, and welders tested under supervision of, National Certified Pipe Welding Bureau (NCPWB).
 - 2. Brazing: Certify brazing procedures, brazers and operators in accordance with ASME Boiler and Pressure Vessel Code, Section IX, for shop and job-site brazing of piping work.

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3. NSF Labels: Where plastic piping is indicated to transport potable water, provide pipes and pipe fittings bearing approval label by National Sanitation Foundation (NSF).
 4. Lead Free Compliance: All components associated with potable water systems (including, but not limited to, valves, end use devices/fixtures, pipe, pipe fittings, solder/flux, etc.) shall be "lead-free" in accordance with all local, state and federal codes, as well as NSF/ANSI 372 (NSF 61-G).
- B. Pipe Testing Procedures: Contractor shall pressure test all piping systems in accordance with the following:
1. ASME Code for Pressure Piping B31, most current edition.
 2. National Fire Protection Association (NFPA), all applicable sections, most current edition.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of pipe and pipe fitting. In addition, submit a matrix indicating each service and the proposed pipe material and fitting.
- B. Welding Certifications: Submit reports as required for piping work.
- C. Brazing Certifications: Submit reports as required for piping work.
- D. Maintenance Data: Submit maintenance data and parts lists for each type of mechanical fitting. Include this data, product data, and certifications in maintenance manual; in accordance with requirements of Division-01.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Except for hub-and-spigot and similar units of pipe, provide factory-applied plastic end-caps on each length of pipe and tube. Maintain end-caps through shipping, storage and handling as required to prevent pipe-end damage, and eliminate dirt and moisture from inside of pipe and tube.
- B. Where possible, store pipe and tube inside and protected from weather. Where necessary to store outside, elevate above grade and enclose with durable, waterproof wrapping.
- C. Protect flanges and fittings from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Piping Materials: Provide pipe and tube of type, joint type, grade, size and weight (wall thickness or Class) indicated for each service; where type, grade or class is not indicated. Provide proper selection as determined by Installer for installation requirements, and comply with governing regulations and industry standards.
- B. Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve or equipment connection in each case. Where not otherwise indicated, comply with governing regulations and industry standards for selections, and with pipe manufacturer's recommendations where applicable.

2.2 STEEL PIPES AND PIPE FITTINGS

- A. Black Steel Pipe: ASTM A 53, A 106 or A 120; except comply with ASTM A 53 or A 106 where close coiling or bending is required.
- B. Galvanized Steel Pipe: ASTM A 53 or A 120; except comply with ASTM A 53 where close coiling or bending is required.
- C. Seamless Steel Pipe: ASTM A 53, A 106, or A 120; except comply with ASTM A 53 or A 106 where close coiling or bending is required.
- D. Galvanized Seamless Steel Pipe: ASTM A 53 or A 120; except comply with ASTM A 53 where close coiling or bending is required.
- E. Electric-Resistance-Welded Steel Pipe: ASTM A 135.
- F. Electric-Fusion-Welded Steel Pipe: ASTM A 671, A 672, or A 691.
- G. Stainless Steel Pipe: ASTM A 312; Grade TP 304.
- H. Steel Water Pipe: AWWA C200 for pipe 6" (150 mm) and larger.
- I. Coal Tar Protective Coatings and Linings for Steel Water Pipe: AWWA C203 for enamel and tape, hot applied.
- J. Cast-Iron Flanged Fittings: ANSI B16.1, including bolting.
- K. Cast-Iron Threaded Fittings: ANSI B16.4.
- L. Malleable-Iron Threaded Fittings: ANSI B16.3; plain or galvanized as indicated.
- M. Malleable-Iron Threaded Unions: ANSI B16.39; selected by Installer for proper piping fabrication and service requirements, including style, end connections, and metal-to-metal seats (iron, bronze or brass); plain or galvanized as indicated.

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- N. Threaded Pipe Plugs: ANSI B16.14.
- O. Steel Flanges/Fittings: ANSI B16.5, including bolting and gasketing of the following material group, end connection and facing, except as otherwise indicated.
 - 1. Material Group: Group 1.1.
 - 2. End Connections: Buttwelding.
 - 3. Facings: Raised-face.
- P. Steel Pipe Flanges for Waterworks Service: AWWA C207.
- Q. Corrosion-Resistant Cast Flanges/Fittings: MSS SP-51, including bolting and gasketing.
- R. Forged-Steel Socket-Welding and Threaded Fittings: ANSI B16.11 except MSS SP-79 for threaded reducer inserts; rated to match schedule of connected pipe.
- S. Wrought-Steel Buttwelding Fittings: ANSI B16.9, except ANSI B16.28 for short-radius elbows and returns; rated to match connected pipe.
- T. Stainless Steel Buttwelding Fittings: MSS SP-43.
- U. Cast-Iron Threaded Drainage Fittings: ANSI B16.12.
- V. Forged Branch-Connection Fittings: Except as otherwise indicated, provide type as determined by Installer to comply with installation requirements.
- W. Pipe Nipples: Fabricated from same pipe as used for connected pipe; except do not use less than Schedule 80 pipe where length remaining unthreaded is less than 1-1/2" (40 mm), and where pipe size is less than 1-1/2" (40 mm), and do not thread nipples full length (no close-nipples).

2.3 COPPER TUBE AND FITTINGS

- A. Copper Type: ASTM B 88; Type (wall thickness) as indicated for each service; hard-drawn temper, except as otherwise indicated.
- B. DWV Copper Tube: ASTM B 306.
- C. ACR Copper Tube: ASTM B 280.
- D. Cast-Copper Solder-Joint Fittings: ANSI B16.18.
- E. Wrought-Copper Solder-Joint Fittings: ANSI B16.22.
- F. Cast-Copper Solder-Joint Drainage Fittings: ANSI B16.23.
- G. Wrought-Copper Solder-Joint Drainage Fittings: ANSI B16.29.

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- H. Cast-Copper Flared Tube Fittings: ANSI B16.26.
- I. Bronze Pipe Flanges/Fittings: ANSI B16.24.
- J. Copper-Tube Unions: Provide standard products recommended by manufacturer for use in service indicated.

2.4 CAST-IRON PRESSURE PIPES AND PIPE FITTINGS

- A. Ductile-Iron Pipe: ANSI A21.51; AWWA C151.
- B. Polyethylene Encasement for Gray and Ductile Cast-Iron Piping: ANSI A21.5; AWWA C105.
- C. Cast-Iron Fittings: AWWA C110.
- D. Gray-Iron Fittings: AWWA C110.
- E. Ductile-Iron Fittings: AWWA C110.
- F. Rubber-Gasket Joints: AWWA C111.

2.5 CAST-IRON SOIL PIPES AND PIPE FITTINGS

- A. Hubless Cast-Iron Soil Pipe: FS WW-P-401.
- B. Cast-Iron Hub-and-Spigot Soil Pipe: ASTM A 74.
- C. Hubless Cast-Iron Soil Pipe Fittings: Neoprene gasket complying with ASTM C 564 and stainless steel clamp holding band.
- D. Cast-Iron Hub-and-Spigot Soil Pipe: Match soil pipe units; complying with same standards (ASTM A 74).
- E. Compression Gaskets: ASTM C 564.

2.6 PLASTIC PIPE AND FITTINGS

- A. Polypropylene Pipe: Unplasticized, unpigmented. Materials shall comply with FDA, USDA, 3A and USP XX Class VI sanitary standards. Pipe ferruled ends shall be field produced with factory supply flange former.
- B. Virgin Rigid Polyvinyl Chloride (PVC) Schedule 40 Pipe: Solid wall pipe with a cell class of 12454. Materials shall comply with ASTM D 1784, ASTM D 1785, ASTM D 2665 and NSF Standards 14 and 61.
- C. Virgin Rigid Polyvinyl Chloride (PVC) Schedule 80 Pipe: Solid wall pipe with a cell class of 12454. Materials shall comply with ASTM D 1784, ASTM D 1785, and NSF Standards 14 and 61.

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- D. Virgin Rigid Chlorinated Polyvinyl Chloride (CPVC) Pipe: Copper Tube Size (CTS), Standard Dimensional Ratio (SDR) 11 with a cell class of 24448. Materials shall comply with ASTM D 1784, ASTM D 2846, and NSF Standards 14 and 61.
- E. Fittings for Propylene Pipe: Same resin as piping with molded sanitary ferruled ends. Fittings shall be joined with PVDF true union sanitary clamps and sealed with silicone gaskets. Pipe, fittings, gaskets, clamps and flange forming material shall be provided by same manufacturer.
- F. Fittings for PVC Schedule 40 Pipe:
 1. Injection molded PVC DWV fittings: ASTM D 2665.
 2. Fabricated PVC DWV fittings: ASTM F 1866.
 3. All fittings shall conform to NSF Standard 14.
- G. Fittings for PVC Schedule 80 Pipe:
 1. Injection molded PVC DWV fittings: ASTM D 2467.
 2. Threaded PVC Schedule 80 fittings: ASTM D 2464.
 3. All fittings shall conform to NSF Standards 14 and 61.
- H. Fittings for CPVC Pipe: ASTM D 2846, NSF Standards 14 and 61.

2.7 FOUNDATION DRAINAGE TILE AND PIPE FITTINGS, AND ACCESSORIES

- A. Rigid Perforated Polyvinyl Chloride Pipe (PVC): ASTM D 2729; perforated except where standard sections of pipe are indicated.
- B. Fittings for Accessories for Foundation Drainage Tile and Pipe: Unless otherwise indicated, match and of same material as pipe units; comply with same standards, where applicable, except fittings need not be perforated where pipe is required to be perforated.

2.8 MISCELLANEOUS PIPING MATERIALS/PRODUCTS

- A. Welding Materials: Except as otherwise indicated, provide welding materials as determined by Installer to comply with installation requirements.
 1. Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials.
- B. Soldering Materials: Except as otherwise indicated, provide soldering materials as determined by Installer to comply with installation requirements.
 1. Tin-Antimony Solder: ASTM B 32, Grade 95TA.
 2. Silver Solder: ASTM B 32, Grade 96TS.

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- C. Brazing Materials: Except as otherwise indicated, provide brazing materials as determined by Installer to comply with installation requirements.
 - 1. Comply with SFA-5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials.
- D. Gaskets for Flanged Joints: ANSI B16.21; full-faced or cast-iron raised face for steel flanges, unless otherwise indicated.
- E. Piping Connectors for Dissimilar Non-Pressure Pipe: Elastomeric annular ring insert, or elastomeric flexible coupling secured at each end with stainless steel clamps, sized for exact fit to pipe ends and subject to approval by plumbing code.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently-leakproof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings, but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16" (1.6 mm) misalignment tolerance.
 - 1. Comply with ANSI B31 Code for Pressure Piping.
- B. Locate piping runs, except as otherwise indicated, vertically and horizontally (pitched to drain) and avoid diagonal runs wherever possible. Where trapping is unavoidable, install drain valve with 3/4" (20 mm) hose end connection, cap and chain. Provide access panels as required. Orient horizontal runs parallel with walls and column lines. Locate runs as shown or described by diagrams, details and notations or, if not otherwise indicated, run piping in shortest route which does not obstruct usable space or block access for servicing building and its equipment. Hold piping close to walls, overhead construction, columns and other structural and permanent enclosure elements of building; limit clearance to 1/2" (13 mm) where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any. Where possible, locate insulated piping for 1" (25 mm) clearance outside insulation. Wherever possible in finished and occupied spaces, conceal piping from view, by locating in column enclosures, in hollow wall construction or above suspended ceilings; do not encase horizontal runs in solid partitions, except as indicated.
- C. Exposed piping in finished areas shall be covered with a 16 gauge steel cover primed and painted, secured to an adjacent structure and painted to match adjacent surfaces.
- D. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures unless unavoidable. Install drip pan under piping that must be run through electrical spaces.

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3.2 PIPING SYSTEM JOINTS

- A. General: Provide joints of type indicated in each piping system.
 - 1. Thread pipe in accordance with ANSI B2.1; cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint compound, or pipe joint tape (Teflon) where recommended by pipe/fitting manufacturer, on male threads at each joint and tighten joint to leave not more than 3 threads exposed.
 - 2. Braze copper tube-and-fitting joints where indicated, in accordance with ASME B31.
 - 3. Solder copper tube-and-fitting joints where indicated, in accordance with recognized industry practice. Cut tube ends squarely, ream to full inside diameter, and clean outside of tube ends and inside of fittings. Apply solder flux to joint areas of both tubes and fittings. Insert tube full depth into fitting, and solder in manner which will draw solder full depth and circumference of joint. Wipe excess solder from joint before it hardens.
- B. Weld pipe joints in accordance with ASME Code for Pressure Piping, B31.
- C. Weld pipe joints in accordance with recognized industry practice and as follows:
 - 1. Weld pipe joints only when ambient temperature is above 0°F (-18°C) where possible.
 - 2. Bevel pipe ends at a 37.5° angle where possible, smooth rough cuts, and clean to remove slag, metal particles and dirt.
 - 3. Use pipe clamps or tack-weld joints with 1" (25 mm) long welds; 4 welds for pipe sizes to 10" (250 mm), 8 welds for pipe sizes 12" (300 mm) to 20" (500 mm).
 - 4. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes and non-metallic inclusions.
 - 5. Do not weld-out piping system imperfections by tack-welding procedures; refabricate to comply with requirements.
 - 6. At Installer's option, install forged branch-connection fittings wherever branch pipe is indicated; or install regular "T" fitting.
 - 7. At Installer's option, install forged branch-connection fittings wherever branch pipe of size smaller than main pipe is indicated; or install regular "T" fitting.
- D. Weld pipe joints of steel water pipe in accordance with AWWA C206.
- E. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform

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compression of gaskets.

- F. Lead Joint Installation: Tightly pack joint with joint packing material. Do not permit packing to enter bore of finished joint. Clean joint after packing. Fill remaining joint space with one pouring of lead to indicated minimum depth measured from face of bell. After lead has cooled, caulk joint tightly by use of hammer and calking iron.
- G. Hubless Cast-Iron Joints: Comply with coupling manufacturer's installation instructions.
- H. Plastic Pipe/Tube Joints: Comply with manufacturer's instructions and recommendations, and with applicable industry standards:
 - 1. Heat Joining of Thermoplastic Pipe: ASTM D 2657.
 - 2. Making Solvent-Cemented Joints: ASTM D 2235, and ASTM F 402.
- I. Open Drain-Tile Joints: Except as otherwise indicated, provide 1/4" (6 mm) open joint with top 2/3 of annular space covered by joint accessory material.

3.3 PIPING INSTALLATION

- A. Install drain tile piping from lowest end of slope to highest, solidly bedded in filtering or drainage fill. Shape bed for bells of piping (if any). Place bells/hubs of units up-stream. Lay perforated pipe with perforations down. Refer to Division-2 specifications for filter cloth, bedding material and backfill installation requirements.
- B. Install ductile cast-iron water mains and appurtenances in accordance with-AWWA C600.

3.4 RADIOGRAPHIC (X-RAY) TESTING

- A. Field weld joints for all black steel pipe shall be radiographically (x-ray) tested to the extent identified below.
- B. Testing shall be conducted by an independent testing company. The testing company shall provide arrest report identifying the results of each weld tested (pass/fail).
- C. The Contractor shall engage the Owner and Engineer of Record to identify welds to be tested.
- D. Testing:
 - 1. If the total quantity of field welds is greater than 50, test 10% of field welds.
 - 2. If the total quantity of field welds is less than 50, test 25% of field welds.
 - 3. Should any of the initial welds tested fail, Contractor will be required to test an additional 20% of all remaining welds, at no additional cost to the Owner.
 - 4. Should any of the additional 20% of welds tested fail, Contractor will be requested

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to test 100% of all remaining welds, at no additional cost to the Owner.

3.5 PIPE TESTING

- A. The mechanical contractor shall air and/or hydrostatically test the following systems in accordance with the latest ASME B31 (ASME Code for Pressure Piping) and NFPA requirements.
 - 1. Hydrostatic Test:
 - a. Domestic Water
- B. Pressure tests shall also be performed prior to the installation of all insulation materials.
- C. Hydrostatic Test: Provide temporary equipment for testing, including pump and gages. Test piping system before insulation is installed, wherever feasible and remove control devices before testing. Test each natural section of each piping system independently, but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with water and pressurize for indicated pressure and time.
 - 1. Required test period is four (4) hours.
 - 2. Hydrostatically test each piping system at 150% of operating pressure indicated, but not less than 100 psi (690 kPa) test pressure.
 - 3. Observe each test section for leakage at end of test period. Test fails if leakage is observed or if pressure drop exceeds less than zero percent (0.0%) of test pressure.
 - 4. Upon completion of roughing-in and before setting fixtures, the entire new domestic water system shall be tested. Where a portion of the water piping system is to be concealed before completion, this portion shall be tested separately in a manner described for the entire system.
 - 5. Prior to testing, verify the pressures listed above are in accordance with the latest ASME B31 code and NFPA. Should a discrepancy exist between the ASME B31 code, NFPA, and/or the pressures indicated above, contact the Engineer prior to testing.
- D. Sanitary and Storm Water Piping Systems:
 - 1. All soil, waste, vent and storm water piping shall be tested by the Contractor and reviewed by the Architect before acceptance. All piping located underground shall be tested before backfilling. The costs of all equipment required for tests are to be included under the contract price.
 - 2. The entire new drainage system and venting system shall have all necessary openings plugged and filled with water to the level of the highest vent stack above the roof or to the maximum pressure rating of the joint used. The system shall hold

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this water for four (4) hours without showing a drop in water level. Where a portion of the system is to be tested, the test shall be conducted in the same manner as described for the entire system, except a vertical stack 10 feet (3000 mm) above the highest horizontal line to be tested may be installed and filled with water to maintain sufficient pressure, or a pump may be used to supply the required pressure.

3. Where sections are tested, overlap the sections so that all joints are subjected to the test procedures.
- E. Drain test water from piping systems after testing and repair work has been completed.
- F. Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.
- G. Contractor shall submit pipe leakage test results to the A/E within 72 hours of completed tests. Only test results that meet the specified leakage requirements shall be submitted. Pipe test results shall be recorded on the attached "Piping Leakage Test Summary Form - Plumbing" at the end of this section; no other forms will be accepted. In addition, the pipe leakage submittals shall include 11x17 drawing(s) as required to clearly indicate the full extent of the pipe test section (each pipe test section shall be numbered and color coded).
- H. All pipe leakage test results shall be included with the final TAB report and the O&M Manual.

3.6 CLEANING, FLUSHING, INSPECTING

- A. General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any). Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports and accessory items.
 1. Inspect pressure piping in accordance with procedures of ASME B31.
- B. Disinfect water mains and water service piping in accordance with AWWA C601.
- C. After final testing for leaks, all new potable water lines shall be thoroughly flushed by plumbing contractor to remove foreign material. Before placing the systems in service, Contractor shall engage a qualified service organization, to sterilize the systems in accordance with the following procedure:
 1. Through a 3/4" (20 mm) hose connection in the main entering the building, pump in sufficient sodium hypochlorite to produce a free available chlorine residual of not less than 200 PPM. Plumbing contractor shall provide plumbing connections and power for pumping chlorine into the system.
 2. Proceed upstream from the point of chlorine application opening all faucets and taps until chlorine is detected. Close faucets and taps when chlorine is evident.

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3. When chlorinated water has been brought to every faucet and tap with a minimum concentration of 200 PPM chlorine, retain this water in the system for three hours. CAUTION: Over-concentration of chlorine and more than three (3) hours of retention may result in damage to piping system.
4. At the end of the retention period, no less than 100 PPM of chlorine shall be present at the extreme end of the system.
5. Proceed to open all faucets and taps and thoroughly flush all new lines until the chlorine residual in the water is less than 1.0 PPM.
6. Obtain representative water samples from the system for analysis by a recognized bacteriological laboratory.
7. If the sample tested for coliform organisms is negative, a letter and laboratory reports shall be submitted by the service organization to the Contractor, certifying successful completion of the sterilization.
8. If any samples tested indicate the presence of coliform organisms, the entire sterilization procedure shall be repeated.

END OF SECTION 220514

**PIPING LEAKAGE TEST SUMMARY FORM
(PLUMBING)**

Project Name:

Project
Number:

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System Tested	Sections Tested (1)	System Operating Pressure	Test Pressure (PSI/FT-HD) (2)	Duration (3)	Pressure Drop (4)	Pass/Fail

Name of Testing Agency/Company: _____

Date of Test(s): _____

Test Conducted By (Print/Sign): _____

- (1) Identified by an 11 x 17 numbered and color coded test section plan. Plan shall accompany this test report.
- (2) 150% of operating pressure but not less than 100 psi , 200 psi for air-gas-vacuum, 10 ft. static head pressure or to the maximum rating of the joint. Include joint cut sheets showing their ratings.
- (3) Four (4) hours minimum.
- (4) Shall not exceed 0.0%.

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SECTION 220515 - PIPING SPECIALTIES FOR PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of piping specialties work required by this section is indicated on drawings and schedules and by requirements of this section.
- B. Types of piping specialties specified in this section include the following:
 - 1. Pipe Escutcheons
 - 2. Pipeline Strainers
 - 3. Vandal-Proof Vent Caps
 - 4. Dielectric Fittings
 - 5. Mechanical Sleeve Seals
 - 6. Penetration Seals
 - 7. Water Hammer Arresters
 - 8. Drip Pans
 - 9. Pipe Sleeves
 - 10. Sleeve Seals
 - 11. Flexible Connector
 - 12. Electric Pipe Trace
- C. Piping specialties furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-22 sections.

1.2 QUALITY ASSURANCE

- A. Codes and Standards:
 - 1. FCI Compliance: Test and rate "Y" type strainers in accordance with FCI 73-1 "Pressure Rating Standard for "Y" Type Strainers". Test and rate other type strainers in accordance with FCI 78-1 "Pressure Rating Standard for Pipeline Strainers Other than "Y" Type".

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2. Lead Free Compliance: All components associated with potable water systems (including, but not limited to, valves, end use devices/fixtures, pipe, pipe fittings, solder/flux, etc.) shall be "lead-free" in accordance with all local, state and federal codes, as well as NSF/ANSI 372 (NSF 61-G).

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions, and dimensioned drawings for each type of manufactured piping specialty. Include pressure drop curve or chart for each type and size of pipeline strainer. Submit schedule showing manufacturer's figure number, size, location, and features for each required piping specialty.
- B. Shop Drawings: Submit for fabricated specialties, indicating fabrication, materials, and method of support.
- C. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured piping specialty. Include this data, product data, and shop drawings in maintenance manual.

PART 2 - PRODUCTS

2.1 PIPING SPECIALTIES

- A. General: Provide factory-fabricated piping specialties recommended by manufacturer for use in service indicated. Provide piping specialties of types and pressure ratings indicated for each service, or if not indicated, provide proper selection to comply with installation requirements. Provide sizes as indicated, and connections, which properly mate with pipe, tube, and equipment connections.

2.2 PIPE ESCUTCHEONS

- A. General: Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.
- B. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged.
- C. Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.

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2.3 LOW PRESSURE Y-TYPE PIPELINE STRAINERS

- A. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125 psi (850 kPa) working pressure, with Type 304 stainless steel screens, with perforations as follows:
 - 1. Piping 2" (50 mm) and Smaller: 1/32" (.8 mm) diameter perforations.
 - 2. Piping 2-1/2" (65 mm) and Larger: 3/64" (1.2 mm) diameter perforations for water systems and 1/16" diameter perforations for steam systems.
- B. Threaded Ends, 2" (50 mm) and Smaller: Brass, screwed screen retainer with centered blowdown fitted with valve and pipe plug.
- C. Threaded Ends, 2-1/2" (65 mm) and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with valve and pipe plug.
- D. Flanged Ends, 2-1/2" (65 mm) and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with valve and pipe plug.
- E. Butt Welded Ends, 2-1/2" (65 mm) and Larger: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with valve and pipe plug.
- F. Grooved Ends, 2-1/2" (65 mm) and Larger: Tee pattern, ductile-iron or malleable-iron body and access end cap, access coupling with EDPM gasket.

2.4 VANDAL-PROOF VENT CAPS

- A. General: Provide cast-iron vandal-proof vent caps, full size of vent pipe, caulked base connection for cast-iron pipes, threaded base for steel pipes.

2.5 DIELECTRIC FITTINGS

- A. General: Provide assembly or fitting having insulating material to isolate dissimilar metals to prevent galvanic action and stop corrosion.
 - 1. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - a. Provide separate companion flanges and steel bolts and nuts for 150- or 300-psig (1035 kPa or 2070 kPa) minimum working pressure to suit system pressures.
 - 2. Dielectric Nipples: Electroplated steel nipple, having inert and non-corrosive thermoplastic lining, with combination of plain, threaded, or grooved end types and 300-psig (2070 kPa) working pressure at 225°F (107°C) temperature.
 - 3. Dielectric unions shall NOT be acceptable.

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2.6 MECHANICAL SLEEVE SEALS

- A. General: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

2.7 PENETRATION SEALS

- A. Provide seals for all openings through fire-rated walls, floors, or ceilings used as passage for mechanical piping. See Division-22 Section "Basic Plumbing Materials and Methods" for penetration seals and firestopping requirements.
- B. Provide seals for all openings through walls, floors or ceilings used as passage for mechanical components such as piping.

2.8 WATER HAMMER ARRESTERS

- A. General: Provide bellows type water hammer arresters, stainless steel casing and bellows, pressure rated for 250 psi (1724 kPa), tested and certified in accordance with PDI Standard WH-201.

2.9 FABRICATED PIPING SPECIALTIES

- A. Drip Pans: Provide drip pans fabricated from corrosion-resistant sheet metal with watertight joints, and with edges turned up 2-1/2" (65 mm). Reinforce top, either by structural angles or by rolling top over 1/4" (6 mm) steel rod. Provide hole, gasket, and flange at low point for watertight joint and 1" (25 mm) drain line connection.
- B. Pipe Sleeves: Provide pipe sleeves of one of the following:
1. Sheet-Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate from the following gages: 3" (75 mm) and smaller, 20 gage (1.0 mm); 4" to 6" (100 mm to 150 mm), 16 gage (1.6 mm); over 6" (150 mm), 14 gage (2 mm).
 2. Steel-Pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs.
 3. Iron-Pipe: Fabricate from cast-iron or ductile-iron pipe; remove burrs.

2.10 FLEXIBLE CONNECTORS

- A. Furnish and install braided stainless steel flexible connectors on the inlet and outlet of each pump, chiller, cooling tower, and all other piping connected to a vibrating piece of equipment. Construction shall be of annular corrugated stainless steel close-pitch hose with stainless steel overbraid.

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1. The corrugated metal hose, braids, and a stainless steel ring-ferrule/band (material gauge not less than .048") (material gauge not less than 1.2 mm) shall be integrally welded using a 100% circumferential, full-penetration TIG weld.
2. End fittings shall be flat-face plate steel flanges with 150#ANSI drilling and outside diameter. Fittings shall be attached using a 100% circumferential TIG/MIG weld.
3. Braided stainless steel connectors shall be suitable for operating temperatures up to 850°F (454°C).
4. The rated working pressure of braided metal hose shall have a minimum 4:1 safety factor based on an operating temperature of 70°F (20°C). Each braided stainless steel connector shall be individually leak tested by the manufacturer using air-under-water or hydrostatic pressure.
5. Flanged connectors shall be prepared for shipment using cut-to-length spacers, securely positioned between the flanges to prevent axial compression damage and maintain the manufactured length. Spacers must be removed prior to system start-up.
6. All braided stainless steel connectors shall be covered by a three (3) year warranty.
7. Minimum overall lengths shall be as follows:

Through 4" (100 mm) diameter:	9" (225 mm)
5" (125 mm), 6" (150 mm) diameter:	11" (275 mm)
Over 6" (150 mm) diameter:	1.5 times nominal diameter

2.11 ELECTRIC PIPE TRACING

- A. Furnish and install self-regulating pipe trace heater consisting of two (2) 16 AWG nickel plated copper bus parallel wires embedded in a self-regulating polymer core that varies its power output to respond to temperature along its length, allowing the heater to cross over itself without overheating, and to be cut to length in the field. The heater shall be covered by a radiation cross linked polyethylene dielectric jacket rated at 300 VAC at 222°F (105°C) with VW-1 flame resistance.
- B. The heater shall operate on line voltage 120V, without the use of transformers.
- C. The heater shall be sized according to the following table. The output rating is in watts per linear foot at 50°F (10°C).

<u>Pipe Size</u>	<u>Heater Capacity</u>
1/2 - 1 inch (13 mm - 25 mm)	3 W/LF (1 W/m)
1-1/4 - 2 inch (32 mm - 50 mm)	5 W/LF (1.6 W/m)

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3 inch (75 mm)	5 W/LF (1.6 W/m)
4 inch (100 mm)	8 W/LF (2 W/m)
6 inch (150 mm)	8 W/LF (2 W/m)
8 inch (200 mm)	2 strips - 8 W/LF (2 W/m)
10 - 14 inch (250 mm - 350 mm)	2 strips - 8 W/LF (2 W/m)

- D. All heating cable cores shall be permanently marked with manufacturer's batch or serial number for traceability. All cable jackets shall be continuously marked with manufacturer's name, catalog number, nominal supply voltage and nominal power output in watts per foot. Use of temporary printing or tags not permitted.
- E. All cables shall be capable of withstanding 1,600 VAC RMS (50 to 60 HZ) applied for one minute between the parallel conductors and the metallic braid.
- F. Power retention of the heating element shall be a minimum of 90% after a minimum of 30 thermal cycles between 50°F and 150°F (10°C and 66°C).
- G. Power connection, end seal, splice and tee kit components shall be applied in the field.
- H. The system shall be controlled by an ambient sensing thermostat set at 40°F.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

- A. Pipe Escutcheons: Install pipe escutcheons on each pipe penetration thru floors, walls, partitions, and ceilings where penetration is exposed to view; and on exterior of building. Secure escutcheon to pipe or insulation so escutcheon covers penetration hole, and is flush with adjoining surface.
- B. Y-Type Strainers: Install Y-type strainers full size of pipeline, in accordance with manufacturer's installation instructions. Install pipe nipple and shutoff valve in strainer blow down connection, full size of connection, except for strainers 2" (50 mm) and smaller installed ahead of control valves feeding individual terminals. Where indicated, provide drain line from shutoff valve to drain, full size of blow down connection.
 - 1. Locate Y-type strainers ahead of the following equipment, and elsewhere as indicated, if integral strainer is not included in equipment:
 - a. Pumps
 - b. Pressure reducing valves
 - c. Temperature or pressure regulating valves

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- C. Vandal-Proof Vent Caps: Install vandal-proof vent caps on each vent pipe passing through roof, and elsewhere as indicated. Locate base of vent cap 6" (150 mm) above roof surface, or higher where required by Code.
- D. Dielectric Fittings: Install at each piping joint between ferrous and non-ferrous piping. Comply with manufacturer's installation instructions.
- E. Mechanical Sleeve Seals: Provide mechanical sleeve seals for sleeves located in foundation walls below grade, or in exterior walls. Loosely assemble rubber links around pipe with bolts and pressure plates located under each bolt head and nut. Push into sleeve and center. Tighten bolts until links have expanded to form watertight seal.
- F. Water Hammer Arresters: Install in upright position, in locations and of sizes in accordance with PDI Standard WH-201, and elsewhere as indicated.

3.2 INSTALLATION OF FABRICATED PIPING SPECIALTIES

- A. Drip Pans: Locate drip pans under piping passing over or within 3' (0.9 m) horizontally of electrical equipment, and elsewhere as indicated. Hang from structure with rods and building attachments, weld rods to sides of drip pan. Brace to prevent sagging or swaying. Connect 1" (25 mm) drain line to drain connection, and run to nearest drain as indicated.
- B. Pipe Sleeves: Install pipe sleeves of types indicated where piping passes through walls, floors, ceilings, and roofs. Do not install sleeves through structural members of work, except as detailed on drawings, or as reviewed by the Owner. Install sleeves accurately centered on pipe runs. Size sleeves so that piping and insulation (if any) will have free movement in sleeve, including allowance for thermal expansion; but not less than two (2) pipe sizes larger than piping run. Where insulation includes vapor-barrier jacket, provide sleeve with sufficient clearance for installation. Install length of sleeve equal to thickness of construction penetrated, and finish flush to surface; except floor sleeves. Sleeves through floors shall be flush with the floor, except for sleeves passing through equipment rooms, toilet rooms (and other wet areas) which shall extend 3/4" (20 mm) above the floor. Space between the pipe and sleeve shall be caulked. Escutcheons plates shall be constructed to conceal the ends of sleeves. Extend floor sleeves 1/4" (6 mm) above level floor finish and 3/4" (20 mm) above floor finish sloped to drain. Provide temporary support of sleeves during placement of concrete and other work around sleeves, and provide temporary closure to prevent concrete and other materials from entering sleeves.
 - 1. Install sheet-metal sleeves at interior partitions and ceilings other than suspended ceilings.
 - 2. Install iron-pipe sleeves at exterior and interior foundation wall penetrations, both above and below grade. Penetrations shall be sealed weathertight.
 - 3. Install steel-pipe except as otherwise indicated.

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3.3 INSTALLATION OF ELECTRIC PIPE TRACING

- A. Provide electric heat trace for all exterior piping, located above the local frost line, including, but not limited to, exterior condenser water piping, cooling tower make-up water piping, exterior chilled water piping, etc.
- B. Install the heater linearly on the pipe after piping has been successfully pressure tested. Secure the heater to piping with cable ties or type PF-1 polyester tape.
- C. Apply "electric traced" signs to the outside of the thermal insulation.
- D. Tests:
 - 1. After installation and before and after installing the thermal insulation, subject heat to testing using a 1000 VDC megger. Minimum installation resistance should be 20 to 1000 megohms regardless of length.
- E. Insulate all piping where heat trace is required. Refer to Division-22 section, Plumbing Insulation for type and thickness.

3.4 INSTALLATION OF FLEXIBLE PIPE CONNECTORS

- A. Provide flexible pipe connectors on the inlet and outlet of piping connected to a vibrating piece of equipment. Flexible connectors shall be full line size as indicated on the drawings and should be provided with control rods.

END OF SECTION 220515

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SECTION 220516 - EXPANSION COMPENSATION FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of expansion compensation products required by this section is indicated on drawings and/or specified in other Division-22 sections.
- B. Types of expansion compensation products specified in this section include the following:
 - 1. Packless Expansion Joints:
- C. Expansion Compensators
- D. Expansion compensation products furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division-22 sections.

1.2 QUALITY ASSURANCE

- A. Codes and Standards:
 - 1. EJMA Compliance: Construct compensation products in accordance with standards of the Expansion Joint Manufacturer's Association (EJMA).

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of expansion compensation product. Submit expansion compensation schedule showing manufacturer's figure number, size, location, and features for each required expansion compensation product.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of expansion compensation product, indicating dimensions, weights, required clearances, and methods of assembly of components.
- C. Shop Drawings: Submit shop drawings for fabricated expansion loops indicating location, dimensions, pipe sizes, and location and method of attachment of anchors.
- D. Maintenance Data: Submit maintenance data and spare parts lists for each type of expansion compensation product. Include this data, product data, and shop drawings in maintenance manual.

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PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include the following:
 1. Flexonics Inc., Metal Hose and Expansion Joint Div.
 2. Keflex HVAC Products, Flex-Weld, Inc.
 3. Metraflex Co.
 4. Mason Industries, Inc.
 5. Vibration Mountings and Controls, Subsidiary of ARX.

2.2 PACKLESS EXPANSION JOINTS

- A. General: Provide packless expansion joints where indicated for piping systems, with materials and pressure/temperature ratings selected by installer to suit intended service. Select packless expansion joints to provide 200% absorption capacity of piping expansion between anchors.
- B. Expansion Compensators: Pressure rated for 60 (415 kPa) psi for low pressure systems, 175 psi (1200 kPa) for high pressure systems; 2-ply phosphor bronze bellows, brass shrouds and end fittings for copper piping systems, or 2-ply stainless steel bellows, carbon steel shrouds and end fittings for steel piping systems. Provide internal guides and anti-torque device, and removable end clip for proper positioning.

2.3 MISCELLANEOUS MATERIALS

- A. Pipe Alignment Guides: Provide factory-fabricated guides, of cast semi-steel or heavy fabricated steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which expansion compensation products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

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3.2 EXPANSION JOINTS

- A. General: Install expansion joints where indicated, and elsewhere as required for adequate expansion of installed piping system. Install in accordance with manufacturer's instructions. Provide pipe anchors and pipe alignment guides as indicated, and in accordance with manufacturer's recommendations. Align units properly to avoid end loading and torsional stress.

3.3 EXPANSION LOOPS

- A. General: Fabricate expansion loops as indicated, in locations indicated, and elsewhere as required for adequate expansion of installed piping system. Subject loop to cold spring which will absorb 50% of total expansion between hot and cold conditions. Provide pipe anchors and pipe alignment guides as required to properly anchor piping in relationship to expansion loops.

3.4 EXPANSION COMPENSATION FOR RISERS AND TERMINALS

- A. General: Install connection between piping mains and risers with at least five (5) pipe fittings including tee in main. Install connections between piping risers and terminal units with at least four (4) pipe fittings including tee in riser.

3.5 INSTALLATION OF ANCHORS

- A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ANSI B31, and to prevent transfer of loading and stresses to connected equipment.
- B. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure. Comply with ANSI B31 and with AWS standards.
- C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.
- D. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principle pipe-runs, at intermediate points in pipe-runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

END OF SECTION 220516

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SECTION 220519 - METERS AND GAUGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of meters and gauges required by this section is indicated on drawings and/or specified in other division-22 sections.
- B. Types of meters and gauges specified in this section include the following:
 - 1. Temperature Gauges and Fittings:
 - a. Direct Mount Dial Thermometers
 - b. Remote Reading Dial Thermometers
 - c. Thermometer Wells
 - 2. Pressure Gauges and Fittings:
 - a. Pressure Gauges
 - b. Pressure Gauge Cocks
 - c. Pressure Gauge Connector Plugs
- C. Meters and gauges furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division-22 sections.

1.2 QUALITY ASSURANCE

- A. Codes and Standards:
 - 1. UL Compliance: Comply with applicable UL standards pertaining to meters and gauges.
 - 2. ANSI and ISA Compliances: Comply with applicable portions of American National Standards Institute (ANSI) and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gauges.
 - 3. Lead Free Compliance: All components associated with potable water systems (including, but not limited to, valves, end use devices/fixtures, pipe, pipe fittings, solder/flux, etc.) shall be "lead-free" in accordance with all local, state and federal codes, as well as NSF/ANSI 372 (NSF 61-G).
- B. Certification: Provide meters and gauges whose accuracies, under specified operating conditions, are certified by manufacturer.

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1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of meter and gauge. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gauge schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gauge.
- B. Maintenance Data: Submit maintenance data and spare parts lists for each type of meter and gauge. Include this data in Maintenance Manual.

PART 2 - PRODUCTS

2.1 DIRECT MOUNT DIAL THERMOMETERS

- A. General: Provide direct mount dial thermometers of materials designed and constructed for use in service indicated.
- B. Type: Vapor tension, universal angle.
- C. Case: Drawn steel or brass, glass lens, 5" (125 mm) diameter. For gauges mounted above eight feet (2400 mm), 8" (200 mm) diameter gauge.
- D. Adjustable Joint: Die cast aluminum, 180 degree adjustment in vertical plane, 360 degree adjustment in horizontal plane, with locking device.
- E. Thermal Bulb: Copper with phosphor bronze bourdon pressure tube, one scale division accuracy.
- F. Movement: Brass precision geared.
- G. Scale: Progressive, satin faced, non-reflective aluminum, permanently etched markings.
- H. Stem: Copper plated steel, or brass, for separable socket, length to suit installation.
- I. Range: Conform to the following:
 1. Hot Water: 30°F - 240°F (-1°C - 116°C).
 2. Chilled Water: 30°F - 120°F (-1°C - 49°C).
 3. Air: 40°F - 160°F (4°C - 71°C).

2.2 REMOTE READING DIAL THERMOMETERS

- A. General: Provide remote reading dial thermometers of materials designed and constructed for use in service indicated.
- B. Type: Vapor tension.

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- C. Case: Drawn steel or brass, glass lens, 5" (125 mm) diameter. For gauges mounted above eight feet (2400 mm), 8" (200 mm) diameter shall be used.
- D. Movement: Brass, precision geared.
- E. Tubing: Bronze double braided armor over copper capillary, length to suit installation.
- F. Bulb: Copper with separable socket for liquids, averaging element for air.
- G. Accuracy: + one scale division.
- H. Range: Conform to the following:
 - 1. Hot Water: 30°F - 240°F (-1°C - 116°C).
 - 2. Chilled Water: 30°F - 120°F (-1°C - 49°C).
 - 3. Air: 40°F - 160°F (4°C - 71°C).

2.3 THERMOMETER WELLS

- A. General: Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2" (50 mm) extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.
- B. Manufacturer: Same as thermometers.

2.4 PRESSURE GAUGES

- A. General: Provide pressure gauges of materials designed and constructed for use in service indicated.
- B. Type: General use, 1% accuracy, ANSI B 40.1 Grade A, phosphor bronze bourdon type, bottom connection.
- C. Case: Drawn steel or brass, glass lens, 5" (125 mm) diameter. For gauges mounted above eight feet (2400 mm), 8" (200 mm) gauges shall be used.
- D. Connector: Brass with 1/4" (6 mm) male NPT. Provide protective siphon when used for steam service.
- E. Scale: White coated aluminum, with permanently etched markings.
- F. Range: Conform to the following:
 - 1. Vacuum: 30" Hg (102 kPa) - 15 psi (103 kPa).
 - 2. Water: 0 - 100 psi (0 - 690 kPa).
 - 3. Steam: 0 - 200 psi (0 - 1379 kPa).

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2.5 PRESSURE GAUGE COCKS

- A. General: Provide pressure gauge cocks between pressure gauges and gauge tees on piping systems. Construct gauge cock of brass with 1/4" (6 mm) female NPT on each end, and "T" handle brass plug.
- B. Syphon: 1/4" (6 mm) straight coil constructed of brass tubing with 1/4" (6 mm) male NPT on each end.
- C. Snubber: 1/4" (6 mm) brass bushing with corrosion resistant porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served and pressure rating.
- D. Manufacturer: Same as for pressure gauges.

2.6 PRESSURE GAUGE CONNECTOR PLUGS

- A. General: Provide pressure gauge connector plugs pressure rated for 500 psi (3448 kPa) and 200°F (93°C). Construct of brass and finish in nickel plate, equip with 1/2" (13 mm) NPS fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8" (3 mm) O.D. probe assembly from dial type insertion pressure gauge. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which meters and gauges are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF TEMPERATURE GAUGES

- A. General: Install temperature gauges in vertical upright position, and tilted so as to be easily read by observer standing on floor.
- B. Locations: Install direct mounted thermometers in the following locations, and elsewhere as indicated:
 1. At inlet and outlet of each heat exchanger.
 2. At suction and discharge of each pump.
 3. At discharge of each domestic water heater.
 4. At inlet and outlet of each thermal storage tank.
- C. Remote Reading Dial Thermometers: Install on control panels as indicated. Run tubing between panel and thermometer bulb, adequately supported to prevent kinks. Select

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- tubing length so as to not require coiling of tubing.
- D. Thermometer Wells: Install in piping tee where thermometers are indicated, in vertical upright position. Fill well with oil or graphite, secure cap.

3.3 INSTALLATION OF PRESSURE GAUGES

- A. General: Install pressure gauges in piping tee with pressure gauge cock, located on pipe at most readable position.
- B. Locations: Install in the following locations, and elsewhere as indicated:
1. At suction and discharge of each pump.
 2. At inlet and outlet of each pressure reducing valve.
 3. At incoming services (domestic water, fire and gas).
 4. At inlet and outlet of large strainers.
 5. At inlet and outlet of heat exchangers.
 6. At inlet of expansion tanks.
 7. At inlet and outlet of domestic water booster pump package.
 8. At inlet and outlet of water filtration systems.
 9. At the top of each standpipe riser.
 10. At inlet and outlet of backflow preventers.
- C. Pressure Gauge Cocks: Install in piping tee with snubber.
- D. Pressure Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.

3.4 ADJUSTING AND CLEANING

- A. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.
- B. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked or broken windows and repair any scratched or marred surfaces with manufacturer's touch-up paint.

END OF SECTION 220519

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SECTION 220523 - VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of valves required by this section is indicated on drawings and/or specified in other Division-22 sections.
- B. Types of valves specified in this section include the following:
 - 1. Gate Valves
 - 2. Globe Valves
 - 3. Drain Valves
 - 4. Ball Valves
 - 5. Check Valves
- C. System Descriptions:
 - 1. Domestic Water Piping: Domestic water piping shall relate to potable and non-potable cold water and/or hot water piping systems.
- D. Valves furnished as part of factory-fabricated equipment, are specified as part of the equipment assembly in other Division-22 sections.

1.2 QUALITY ASSURANCE

- A. Valve Types: Provide valves of same type by same manufacturer.
- B. Valve Identification: Provide valves with manufacturer's name (or trademark) and pressure rating and size clearly marked on valve body.
- C. Codes and Standards:
 - 1. MSS Compliance: Mark valves in accordance with MSS-25 "Standard Marking System for Valves, Fittings, Flanges and Unions".
 - 2. ANSI Compliance: For face-to-face and end-to-end dimensions of flanged or welded-end valve bodies, comply with ANSI B16.10 "Face-to-Face and End-to-End Dimensions of Ferrous Valves".
 - 3. UL and FM Compliance: Provide valves used in fire protection piping, which are UL-listed and FM approved.

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4. Lead Free Compliance: All components associated with potable water systems (including, but not limited to, valves, end use devices/fixtures, pipe, pipe fittings, solder/flux, etc.) shall be "lead-free" in accordance with all local, state and federal codes, as well as NSF/ANSI 372 (NSF 61- G).

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of valve. Include pressure drop curve or chart for each type and size of valve. Submit valve schedule showing manufacturer's figure number, size, location, and valve features for each required valve.
- B. Shop Drawings: Submit manufacturer's assembly-type (exploded view) shop drawings for each type of valve, indicating dimensions, weights, materials, and methods of assembly of components.
- C. Maintenance Data: Submit maintenance data and spare parts lists for each type of valve. Include this data, product data, and shop drawings in Maintenance Manual.

PART 2 - PRODUCTS

2.1 VALVES - GENERAL

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work, shall be limited to the following, unless otherwise noted:
 1. Milwaukee
 2. Bray
 3. Apollo
 4. DeZurik
 5. Jamesbury
 6. Watts
- B. Provide factory-fabricated valves recommended by manufacturer for use in service indicated. Provide valves of types and pressure ratings indicated; provide proper selection as determined by Installer to comply with installation requirements. Provide end connections which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option.
- C. Size: Unless otherwise indicated, provide valves of same size as upstream pipe size. Pipe size reduction shall be made after valve assembly.
- D. Valve Features: Provide the following as required:

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1. General: Provide valves with features indicated and, where not otherwise indicated, provide proper valve features as determined by Installer for installation requirements. Comply with ASME B31.9 for building services piping, and ASME B31.1 for power piping.
2. Bypass: Comply with MSS SP-45, and except as otherwise indicated, provide manufacturer's standard bypass piping and valving.
3. Drain: Comply with MSS SP-45, and provide threaded pipe plugs.
4. Flanged: Valve flanges complying with ANSI B16.1 (cast iron), ANSI B16.5, (steel), or ANSI B16.24 (bronze).
5. Threaded: Valve ends complying with ANSI B2.1.
6. Butt-Welding: Valve ends complying with ANSI B16.25.
7. Socket-Welding: Valve ends complying with ANSI B16.11.
8. Solder-Joint: Valve ends complying with ANSI B16.18.
9. Flangeless: Valve bodies manufactured to fit between flanges complying with ANSI B16.1 (cast iron), ANSI B16.5 (steel), or ANSI B16.24 (bronze).
10. Operators: Provide handwheels, fastened to valve stem, for valves other than quarter-turn. Provide lever handle for quarter-turn valves 6" (150 mm) and smaller. Provide gear operators for quarter-turn valves 8" (200 mm) and larger. Provide chain-operated sheaves and chains for overhead valves as indicated.

2.2 GATE VALVES

A. Comply with the following standards:

1. Cast-Iron Valves: MSS SP-70.
2. Bronze Valves: MSS SP-80.
3. Steel Valves: ANSI B16.34.

B. Fire Department Valves (Standpipes):

1. Hose End; 2-1/2" (65 mm): FM, 175 psi (1200 kPa), bronze body, solid wedge, inside screw, non-rising stem, with cap and chain.

C. Fire Protection Services:

1. Threaded End; 2" (50 mm) and Smaller: FM, UL-listed, 175 psi (1200 kPa), bronze body, solid wedge, outside screw and yoke, rising stem. Milwaukee Model 118 or equivalent.
2. Flanged End; 2-1/2" (65 mm) and Larger: FM, UL-listed, 175 psi (1200 kPa), iron

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body bronze mounted, solid wedge, outside screw and yoke, rising stem. Milwaukee Model F2885FP or equivalent.

2.3 GLOBE VALVES

- A. Comply with the following standards:
 - 1. Cast-Iron Valves: MSS SP-85.
 - 2. Bronze Valves: MSS SP-80.
 - 3. Steel Valves: ANSI B16.34.
- B. Domestic Water Piping:
 - 1. 2" (50 mm) and Smaller: Class 150, bronze body, union bonnet, integral seat, renewable TFE disc. Milwaukee Model 590T (Threaded), 1590T (Sweat) or equivalent.
 - 2. Flanged Ends; 2-1/2" (65 mm) and Larger: Class 125, iron body, bolted bonnet, renewable seat and disc, bronze mounted. Milwaukee Model F2981A or equivalent.

2.4 DRAIN VALVES

- A. Comply with the following standards:
 - 1. Water Heater Drain Valves: ASSE 1005.
- B. Domestic Water Piping:
 - 1. 3" (75 mm) and Smaller: Class 125, bronze body ball valve with chrome plated ball, hose end with cap and chain. Milwaukee BA100H (Threaded), Milwaukee BA150H (Sweat) or equivalent.

2.5 BALL VALVES

- A. Comply with the following standards:
 - 1. Bronze Valves: MSS SP-110.
 - 2. Potable Water: NSF-61-8.
- B. Domestic Water Piping:
 - 1. 2" (50 mm) and Smaller: Valves shall be rated 150 psi (1035 kPa) SWP and 600 psi (4140 kPa) non-shock WOG and shall have 2-piece cast ASTM B 584 bronze bodies, TFE seats, standard port, separate packing nut with adjustable stem packing, anti-blowout stems and stainless steel ball. Valve ends shall have full

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depth ANSI threads or extended solder connections and be manufactured to comply with MSS-SP110. Milwaukee BA100S (Threaded), BA150S (Sweat) or equivalent. For potable water applications provide NSF/ANSI 1372 (NSF-61-G) compliant "lead free" valves; Milwaukee UPBA 100/150 or equivalent.

- C. Where piping is insulated, ball valves shall be equipped with 2" (50 mm) extended handles of non-thermal conductive material. Also, provide a protective sleeve that allows operation of the valve without breaking the vapor seal or disturbing the insulation. Memory stops, which are fully adjustable after insulation is applied, shall be included.

2.6 CHECK VALVES

- A. Comply with the following standards:

1. Cast-Iron Valves: MSS SP-71.
2. Bronze Valves: MSS SP-80.
3. Steel Valves: ANSI B16.34.

- B. Domestic Water Piping:

1. 2" (50 mm) and Smaller: Class 150, bronze body, horizontal swing, T pattern with renewable TFE disc. Milwaukee 510T (Threaded), 1510T (Sweat) or equivalent.
2. 2-1/2" (65 mm) and Larger: Class 125, iron body, bolted bonnet, horizontal swing, renewable seat and disc, flanged ends. Milwaukee F2974A or equivalent.

- C. Fire Protection:

1. 2-1/2" (65 mm) and Larger; FM: 175 psi (1200 kPa), iron body bronze mounted, renewable composition disc and bronze seat ring, bolted cover, flanged ends. Milwaukee F2974FP or equivalent.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Except as otherwise indicated, comply with the following requirements.

1. Install valves where required for proper operation of piping and equipment, including valves in branch lines, service mains and all equipment connections. Locate valves so as to be accessible and so that separate support can be provided when necessary.
2. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane unless unavoidable. Install valve drains with hose-end adapter for each valve that must be installed with stem below horizontal plane.

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- B. Insulation: Where insulated, install extended-stem valves, arranged in proper manner to receive insulation.
- C. Mechanical Actuators: Install mechanical actuators with chain operators where indicated. Extend chains to approximately five feet (1500 mm) above floor and secure to clips to clear aisle passage.
- D. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select and install valves with connections to match pipe fittings.
- E. Renewable Seats: Install valves with renewable seats, where applicable.
- F. Fluid Control: Except as otherwise indicated, install gate, ball, globe, and butterfly valves to comply with ANSI B31.9. Where throttling is indicated or recognized as principle reason for valve, install ball, globe or butterfly valves, as indicated.
- G. Installation of Check Valves: Install in horizontal position with hinge pin horizontally perpendicular to center line of pipe. Install for proper direction of flow.

3.2 ADJUSTING AND CLEANING

- A. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.
- B. Valve Identification: Tag each valve in accordance with Division-22 section "Identification for Plumbing Piping and Equipment".
- C. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION 220523

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SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of hangers and supports required by this section is indicated on drawings and/or specified in other Division-22 sections.
- B. Types of hangers and supports specified in this section include the following:
 - 1. Horizontal-Piping Hangers and Supports
 - 2. Vertical-Piping Clamps
 - 3. Hanger-Rod Attachments
 - 4. Building Attachments
 - 5. Saddles and Shields
 - 6. Spring Hangers and Supports
 - 7. Miscellaneous Materials
 - 8. Roof Equipment Supports
 - 9. Anchors
 - 10. Equipment Supports
- C. Hangers and supports furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division-22 sections.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of hangers and supports, of types and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Codes and Standards:
 - 1. Code Compliance: Comply with applicable codes pertaining to product materials and installation of hangers and supports.
 - 2. NFPA, UL, and FM Compliance: Provide products which comply with NFPA 13 listed and labeled by UL and FM where used for fire protection piping systems.

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3. MSS Standard Compliance:

- a. Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-58.
- b. Select and apply pipe hangers and supports, complying with MSS SP-69.
- c. Fabricate and install pipe hangers and supports, complying with MSS SP-89.
- d. Terminology used in this section is defined in MSS SP-90.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing manufacturer's figure number, size, location, and features for each required pipe hanger and support.

PART 2 - PRODUCTS

2.1 HORIZONTAL-PIPING HANGERS AND SUPPORTS

- A. General: Except as otherwise indicated, provide factory-fabricated horizontal-piping hangers and supports complying with MSS SP-58, selected by Installer to suit horizontal-piping systems in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hangers and supports to exactly fit pipe size for bare piping, and to exactly fit around piping insulation with saddle or shield for insulated piping. Provide copper-plated hangers and supports for copper-piping systems. To avoid future electrolysis or corrosion, copper plated hangers, supports, clamps, rod attachments, and building attachments shall not be in direct contact with copper piping. A separation material shall be installed between the pipe and the copper plated hanger, support, clamp, etc. The separation material shall prohibit electrical conductance and prevent galvanic action or corrosion between dissimilar metals. Separation material shall be guaranteed for a minimum of thirty (30) years.

2.2 VERTICAL-PIPING CLAMPS

- A. General: Except as otherwise indicated, provide factory-fabricated vertical-piping clamps complying with MSS SP-58, selected by Installer to suit vertical piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Provide copper-plated hangers and supports for copper-piping systems. To avoid future electrolysis or corrosion, copper plated hangers, supports, clamps, rod attachments, and building attachments shall not be in direct contact with copper piping. A separation material shall be installed between the pipe and the copper plated hanger, support, clamp, etc. The

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separation material shall prohibit electrical conductance and prevent galvanic action or corrosion between dissimilar metals. Separation material shall be guaranteed for a minimum of thirty (30) years.

2.3 HANGER-ROD ATTACHMENTS

- A. General: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments complying with MSS SP-58, selected by Installer to suit horizontal-piping hangers and building attachments, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hanger-rod attachments to suit hanger rods. Provide copper-plated hanger-rod attachments for copper-piping systems. To avoid future electrolysis or corrosion, copper plated hangers, supports, clamps, rod attachments, and building attachments shall not be in direct contact with copper piping. A separation material shall be installed between the pipe and the copper plated hanger, support, clamp, etc. The separation material shall prohibit electrical conductance and prevent galvanic action or corrosion between dissimilar metals. Separation material shall be guaranteed for a minimum of thirty (30) years.

2.4 BUILDING ATTACHMENTS

- A. General: Except as otherwise indicated, provide factory-fabricated building attachments complying with MSS SP-58, selected by Installer to suit building substrate conditions, in accordance with MSS SP-69 and manufacturer's published product information. Select size of building attachments to suit hanger rods. Provide copper-plated building attachments for copper-piping systems. Provide copper-plated hangers and supports for copper-piping systems. To avoid future electrolysis or corrosion, copper plated hangers, supports, clamps, rod attachments, and building attachments shall not be in direct contact with copper piping. A separation material shall be installed between the pipe and the copper plated hanger, support, clamp, etc. The separation material shall prohibit electrical conductance and prevent galvanic action or corrosion between dissimilar metals. Separation material shall be guaranteed for a minimum of thirty (30) years.

2.5 SADDLES AND SHIELDS

- A. General: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.

2.6 SPRING HANGERS AND SUPPORTS

- A. General: Except as otherwise indicated, provide factory-fabricated spring hangers and supports complying with MSS SP-58, selected by Installer to suit piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select spring hangers and supports to suit pipe size and loading.

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2.7 MISCELLANEOUS MATERIALS

- A. Metal Framing: Provide products complying with NEMA STD ML 1.
- B. Steel Plates, Shapes and Bars: Provide products complying with ASTM A 36.
- C. Cement Grout: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2).
- D. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which hangers and supports are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF BUILDING ATTACHMENTS

- A. Install attachments at required locations within concrete steel for proper piping support. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert securely to forms. Where concrete with compressive strength less than 2500 psi (17240 kPa) is indicated, install reinforcing bars through openings at top of inserts.

3.3 INSTALLATION OF HANGERS AND SUPPORTS

- A. General: Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Install supports with maximum spacings complying with MSS SP-69. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.
- B. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers and other accessories. All hangers shall be double nut. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.
- C. Support fire-water piping independently of other piping.
- D. Prevent electrolysis in support of copper tubing by use of hangers and supports which

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are copper plated, or by other recognized industry methods.

E. Provisions for Movement:

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

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

G. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31 Pressure Piping Codes are not exceeded.

H. Insulated Piping: Comply with the following installation requirements.

1. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ANSI B31.

2. Shields: Where low-compressive-strength insulation or vapor barriers are indicated on cold water piping, install coated protective shields.

3. Saddles: Where insulation without vapor barrier is indicated, install protection saddles.

4. For all insulated piping 2-1/2" (63 mm) and larger, provide insulated saddles as follows:

- a. For domestic hot and cold water piping, provide the following:

- b. Minimum 3.75pcf, non-compressive, rigid, phenolic foam insulation. Fire and smoke rating shall be 25/50 or below per ASTM 84.

- c. For cold applications below 75°F (24°C) a zero permeability, abuse resistant, vapor barrier shall be provided with matching butt strips. Apply a full coating of butyl joint sealant in addition to the butt strips for a completely sealed system.

- d. The phenolic foam system shall have a K factor of 0.16 at a mean temperature for 75°F (24°C) and comply with ASTM Standard C1126.

- e. Provide visible inspection sticker at the bottom of each saddle.

- f. Pipe insulation saddles shall be Tru-Balance CoolDry Saddles as manufactured by Buckaroos, Inc. or equivalent.

- I. Spacing: Hanger spacing for piping shall not exceed 8 feet (2400 mm) on centers for pipe 1-1/4" (32 mm) or smaller, and 10 feet (3 m) for pipe 1-1/2" (40 mm) and larger. Regardless of spacing, hangers shall be provided at or near all changes in direction, both vertical and horizontal, for all piping. For cast iron soil pipe, one hanger shall be

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placed at each hub or bell. For PVC piping, hanger spacing shall have 4'-0" space and be installed per manufacturers recommendations.

3.4 ADJUSTMENT OF HANGERS AND SUPPORTS

- A. Adjust hangers and supports and place grout as required under supports to bring piping to proper levels and elevations.

3.5 EQUIPMENT SUPPORTS

- A. Provide concrete housekeeping bases for all floor mounted equipment furnished as part of the work of Division-22. Size bases to extend minimum of 4" (100 mm) beyond equipment base in any direction; and 4" (100 mm) above finished floor elevation. Construct of reinforced concrete, roughen floor slab beneath base for bond, and provide steel rod anchors between floor and base. Locate anchor bolts using equipment manufacturer's templates. Chamfer top and edge corners.
- B. Provide structural steel stands to support equipment not floor mounted or hung from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks mounted on steel stands.

3.6 PAINTING

- A. All hangers, supports, clamps and assemblies shall be primed and painted with rust inhibitors.

END OF SECTION 220529

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SECTION 220548 - VIBRATION ISOLATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Scope: The extent of vibration isolation work to be provided under this Contract is covered by the requirements of this Section, all Division-22 specifications, and the Contract Drawings including structural, architectural, mechanical and electrical which identify equipment and systems requiring vibration isolation treatment.
- B. Types: Types of vibration isolation equipment and systems specified in this Section include:

<u>TYPE</u>	<u>DESCRIPTION</u>
1 Isolator	Ribbed Neoprene Pads
2I Isolator	Neoprene-In-Shear Type
2H Hanger	Rubber-In-Shear Type
3I Isolator	Open Spring Type
3H Hanger	Combination Spring and Neoprene Type
4 Isolator	Vertically Restrained Spring Isolators
5 Thrust	Restraints Spring Type Installed in Pairs
A Base	Directly Bolted Attachment
B Base	Structural Rails or Bases
C Base	Concrete Inertia Type

- C. Selection of Isolators: Provide isolators selected by a vibration isolator equipment specialist.
 1. Conform to isolator types herein specified.
 2. Examine the contract drawings for sizes, horsepowers, rotational speeds, equipment location, length of span between columns and beams and construction type to determine the isolator selection type and deflection required for each piece of mechanical equipment.
 3. Conform to the requirements of the most current edition of American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Handbook, Sound and Vibration Control.

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1.2 QUALITY ASSURANCE

- A. Codes: At a minimum, conform to the most current edition of ASHRAE Handbook.
- B. Manufacturer: Isolators of the same type shall be the product of the same manufacturer. The manufacturer shall publish and maintain a full line of materials, engineering and application data and operating and maintenance instructions.

1.3 SUBMITTALS

- A. Contractor's Certification: Vibration isolator submittals shall include a certification, signed by an officer representing the Contractor and stipulating that the submittal prepared by the manufacturer has been reviewed, and checked on an item by item basis against each piece of mechanical equipment, shown or specified in the Contract Documents, which requires vibration isolation.
- B. Manufacturer's Certification: The manufacturer or manufacturers (if there are more than one) shall each certify that the selections of vibration isolation equipment are based upon the drawings and specifications, and that each piece of mechanical equipment has been examined for rotational speed, equipment type, mounting location, and supporting span between column centers, and that an appropriate isolator has been selected.
- C. Product Data: Furnish manufacturer's product data covering each isolator type for style, characteristic, and finish.
 - 1. Isolator quantities, dimensions, deflections, capacities and types shall remain the responsibility of the manufacturer and the Contractor.
 - a. Shop Drawings: Where coordinated shop drawings are required, provide layout drawings, drawn to a scale of not less than 1/4-inch to 1-foot (6 mm to 300 mm), showing the proposed layout of equipment and piping systems and the location and type of each vibration isolation device.
 - b. Carefully examine other sections requiring coordinated shop drawings and prepare isolation shop drawings to the same scale showing the location of each vibration isolation equipment base, pipe hanger, flexible connection, and isolator.

1.4 STORAGE AND PROTECTION

- A. Storage: Store vibration isolation equipment indoors in the manufacturer's original shipping containers. Preclude the entrance of construction dirt and debris.
 - 1. Vibration isolation equipment and bases, which show signs of rust, cement or concrete fouling, dirt and construction debris shall be disassembled and cleaned, approved or removed from the project site and replaced with new.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include the following:
 1. Mason
 2. Vibration Eliminator Co.
 3. Kinetics Noise Control

2.2 EQUIPMENT

- A. Dimensions: The schedule shows dimensions for deflection and sizes all in inches.
- B. Spans: Where referenced, the schedule shows spans of the longest bay dimension for slabs or beams supported between columns. Dimensions are in feet.
- C. Selection: Exact mounting sizes, dimensions and quantity of isolators and static deflection required shall be determined by the isolator manufacturer based upon equipment that will be furnished and installed by the Contractor under this Contract.
 1. Vibration isolation specialist shall coordinate his work with that of other trades to verify that equipment speeds, in revolutions per minute (rpm), are based upon actual equipment installed at the project site.
 2. Verify that equipment rpm and spring deflection selected are arranged so that resonance is avoided.

2.3 ISOLATOR TYPES

- A. Type 1 Isolators: Provide pad type vibration isolators consisting of either two layers of 3/8-inch (10 mm) thick elastomer, molded to contain a pattern with non-slip characteristics in all directions, and bonded to 16 gauge (1.6 mm) galvanized steel separator plates, or 1-inch (25 mm) thick precompressed molded fiberglass isolation pads. Minimum overall thickness shall be 1-inch (25 mm). Deflection shall be limited to 0.25 inches (6 mm) or less. Loading shall not exceed 40 pounds per square inch (280 kPa).
- B. Type 2I Isolators: Provide double rubber-in-shear or elastomer-in-shear with molded-in steel reinforcement in the top and bottom portions.
 1. Deflections shall be limited to 0.5 inches (13 mm) or less.
 2. Steel bases shall be drilled with mounting holes and equipment mounting points shall be threaded male or female connections.

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3. Treat resilient material with antiozone and antioxidant additives.
- C. Type 2H Hangers: Provide rubber-in-compression suspension hangers, consisting of a formed steel frame and elastomer isolation element and provided with attachments for top and bottom suspension rods.
 1. Design for a minimum 200 percent overload without noticeable deformation or failure.
 2. Metal components shall be galvanized or factory painted.
- D. Type 3I Isolators: Provide adjustable, freestanding, open spring isolators with combination leveling and equipment fastening bases.
 1. Spring elements shall be contained in upper and lower housing assemblies and shall have a minimum Kx-Ky of 0.75.
 2. Design springs for a minimum travel of 50 percent beyond the rated load.
 3. When fully compressed and "bottomed-out", isolators shall be capable of supporting a 150 percent overload without deformation and spring failure.
 4. A minimum 1/4-inch (6 mm) thick non-skid isolation pad shall be bonded to the underside of the base plate.
 5. Size base plates to limit floor loading to 100 pounds per square inch (690 kPa).
 6. Drill base plates for bolting, as required.
 7. Provide means for anchoring the top element of the isolator to rails and equipment.
- E. Type 3H Hangers: Provide combination spring and elastomer hangers consisting of a formed steel frame with coil spring and elastomer insert in compression.
 1. Design hangers to be capable of supporting a 200 percent overload without noticeable deformation or failure.
 2. Design hangers to allow a 30 degree misalignment without binding or a reduction in hanger efficiency.
 3. Design hangers for connection to equipment and supporting rods.
- F. Type 4 Isolators: Provide vertically restrained, freestanding, laterally stable, open spring type isolators.
 1. Design for deflection exceeding 1/2-inch (13 mm).
 2. Provide built-in bearing and leveling provisions.
 3. Provide a minimum 1/4-inch (6 mm) thick non-slip elastomer vibration absorbing pad bonded to the underside of the isolator base.

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4. Outside diameter of each spring shall be equal to or greater than 0.9 times the operating height of the spring under rated load.
 5. Provide vertical limit stops to prevent hyperextension due to wind loads or upward movement when the load is removed. Limit stops shall not bind or inhibit spring movement during normal operating ranges.
 6. For exterior applications, steel housings shall be hot dipped galvanized and springs shall be neoprene or powder coated.
- G. Type 5 Thrust Restraints: Provide spring isolators of an adjustable, freestanding type enclosed within tubular mountings and arranged to be installed in pairs across the discharge of fan flexible connectors.
1. Design restraints to resist the thrust caused by duct internal air pressure.
 2. Install restraints on duct systems with an internal static pressure exceeding 3 inches water gauge (750 Pa).
 3. Restraints shall have the same deflection as isolators installed under the fans.

2.4 BASE TYPES

- A. Type A Bases: No supplementary base is required. Vibration isolators, specified elsewhere, shall be attached directly to the supported equipment or structural system.
- B. Type B, Structural Rails or Bases: Provide bases designed and supplied by the isolation equipment manufacturer.
 1. Construct bases of mill rolled structural sections of sufficient dimension to limit the midpoint deflection or unsupported spans to 1/1440th of the span between isolators.
 2. Include equipment static loadings, power transmission, component misalignment and cantilever loadings when designing structural sections.
 3. When head room is limited, coordinate the design of structural rails and isolators to reduce mounting heights.
 4. Factory finish with two (2) coats of equipment enamel.
- C. Type C, Concrete Inertia Bases: Provide concrete inertia bases designed by the isolator manufacturer and arranged to be filled with concrete in the field.
 1. Construct base of mill rolled structural steel sections, factory mitered and welded into a rigid frame and supporting No. 4 reinforcing bars welded to the structural frame 8 inches (200 mm) on centers both ways and located 2 inches (50 mm) from the bottom of the block.
 2. Arrange for outrigger isolation mountings, anchor bolts and equipment support.

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3. Field fill with 3,000 psi cured-strength concrete. Trowel to a smooth hard finish.
4. Clean structural steel of excess concrete and field paint all steel elements with two coats equipment enamel.
5. Configuration of inertia bases shall be rectangular to accommodate equipment supported unless otherwise indicated.
6. Minimum thickness of inertia bases, in addition to providing suitable mass, shall be sufficient to provide stiffness to maintain equipment manufacturer's recommended alignment and duty efficiency of power transmission.
7. Minimum thickness shall be sufficient to result in a base deflection at midpoint of unsupported span of not more than 1/1440th of the span between isolators.
8. Minimum thickness shall be 8 percent of the longest base dimension unless otherwise specified or indicated.
9. For centrifugal pumps, the bases shall be a minimum 6 inches (150 mm) thick.
10. Where inertia bases are used to mount pumps, the bases shall be long enough to support piping elbows for all connections.

2.5 PIPING

- A. General: All piping in mechanical equipment rooms and within fifty feet (15 m) of the vibration source shall be isolated from the building structure with flexible vibration isolators.
 1. Suspend piping on Type 3H hangers.
 2. Floor-mounted piping shall be supported with Type 4 spring isolators with deflections the same as the equipment to which the piping is attached.
- B. Reciprocating Equipment: Provide spring type hangers with deflections equal to that of reciprocating equipment, with piping arranged with offset elbows to absorb vibration.
- C. Risers: Pipe and duct risers within 100 feet (30 m) of mechanical equipment rooms shall be resiliently anchored to the building structure with Type 1 vibration isolators, near the midpoint of the risers.
 1. Risers shall be isolated and supported at each second floor with pairs of Type 3H hangers, having deflections a minimum of five times the anticipated thermal movement at the support point.
 2. Risers shall be guided as required with four (4) sets of Type 2I vibration isolators.

2.6 VIBRATION ISOLATION SYSTEM SELECTION

- A. General: The following selections of vibration isolation equipment systems shall be

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considered as a minimum. For the equipment below, the following code applies:

Letter (i.e. A, B, C) = Base type

Number (i.e. 1, 2, 3, 4) = Isolator type

Decimal number (i.e. 0.25, 1.5, etc.) = Minimum deflection

B. Refrigeration Reciprocating Compressors

BASEMENT BELOW GRADE	20 FOOT (6 M)	30 FOOT (9 M)	40 FOOT (12 M)
	FLOOR SPAN	FLOOR SPAN	FLOOR SPAN

C 3 0.75	C 3 0.75	C 3 1.5	C 3 2.0
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C. Air Compressors

TYPE EQUIPMENT	BASEMENT BELOW GRADE	20 FOOT (6M) FLOOR SPAN	30 FOOT (9 M) FLOOR SPAN	40 FOOT (12 M) FLOOR SPAN
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Tank Mounted	A 3 0.75	A 3 0.75	A 3 1.5	A 3 2.5
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Base Mounted to 500 rpm (52 Rad/s)	C 3 0.75	C 3 0.75	C 3 0.75	C 3 1.5
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Over 500 rpm (Over 52 Rad/s)	C 3 0.75	C 3 0.75	C 3 1.5	C 3 1.5
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D. Centrifugal Pumps

TYPE EQUIPMENT	BASEMENT BELOW GRADE	20 FOOT (6M) FLOOR SPAN	30 FOOT (9 M) FLOOR SPAN	40 FOOT (12 M) FLOOR SPAN
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Close-coupled thru 7-1/2 hp (5.6 kW)	B or C 2 0.25	C 3 0.75	C 3 0.75	C 3 0.75
Close-coupled 10 hp & above (7.4 kW & above)	C 3 0.75	C 3 0.75	C 3 1.5	C 3 1.5
Bedplate-mounted thru 40 hp (30 kW)	C 3 0.75	C 3 0.75	C 3 1.5	C 3 1.5
50 to 125 hp (37 to 95 kW)	C 3 0.75	C 3 0.75	C 3 1.5	C 3 2.5

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Manufacturer: All vibration isolation equipment shall be installed in accordance with the manufacturer's recommendations.
- B. Manufacturer's Representative: The vibration isolation installation and deflection testing after equipment start-up shall be conducted by a representative of the manufacturer.

3.2 TESTS AND REPORTS

- A. Testing: Each vibration isolation device shall be deflection tested. Two (2) copies of a bound report shall be submitted prior to final acceptance. The certification shall include the following:
 1. Certify that equipment has been isolated in accordance with Contract Drawings, specifications and submittals.
 2. Certify that all minimum specified deflections have been equaled or exceeded.

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3.3 ANCHORING

- A. Installation: Installation shall comply with manufacturer's published recommendations and shall be installed so that isolators are plumb and are operating at a manner for which they were designed.
 - 1. Unless otherwise specified, all equipment shall be securely bolted to isolators, steel bases or concrete inertia bases.
 - 2. Indoor vibration isolators need not be attached to the structure unless required by local codes.
 - 3. Isolators installed outdoors shall be attached to building structure.

3.4 CLEANING

- A. Debris: Remove all debris from under equipment, and thoroughly clean steel bases, inertia bases and check for free movement.
- B. Adjustment: Adjust isolators as required for proper operation prior to starting equipment. Testing of vibration isolators shall be performed by a certified representative of the manufacturer as specified.

3.5 GENERAL

- A. All exterior structural steel and/or steel housings of exterior vibration isolation materials shall be hot dipped galvanized.

END OF SECTION 220548

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SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of plumbing identification work required by this section is indicated on drawings and/or specified in other Division-22 sections.
- B. Types of identification devices specified in this section include the following:
 - 1. Pipe Markers
 - 2. Painted Identification Materials
 - 3. Underground-Type Plastic Line Marker
 - 4. Valve Tags
 - 5. Valve Schedule Frames
 - 6. Engraved Plastic-Laminate Signs
 - 7. Ceiling Identification Markers
 - 8. Plastic Equipment Markers
 - 9. Plasticized Tags
- C. Plumbing identification furnished as part of factory-fabricated equipment, is specified as part of equipment assembly in other Division-22 sections.
- D. Refer to other Division-22 sections for identification requirements at central-station mechanical control center; not work of this section.
- E. Refer to Division-26 sections for identification requirements of electrical work; not work of this section.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Codes and Standards:
 - 1. ANSI Standards: Comply with ANSI A13.1 or Owner standards for lettering size, length of color field, colors, and viewing angles of identification devices.

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1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.
- B. Schedules: Submit valve schedule for each piping system, typewritten and reproduced on 8-1/2" x 11" (213 mm X 275 mm) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and variations for identification (if any). Mark valves which are intended for emergency shut-off and similar special uses, by special "flags", in margin of schedule. In addition to mounted copies, furnish extra copies for maintenance manuals.
- C. Maintenance Data: Include product data and schedules in maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers' products which may be incorporated in the work include the following:
 1. Brady
 2. Seton
 3. Bunting

2.2 PLUMBING IDENTIFICATION MATERIALS

- A. General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division-22 sections. Where more than single type is specified for application, selection is Installer's option but provide single selection for each product category.

2.3 PIPE MARKERS

- A. Snap-on Type: Provide pre-printed, semi-rigid, snap-on color coded identification sleeves complying with ANSI A13.1. This type shall be used for insulated pipe sizes 2" and smaller.
- B. Pressure Sensitive Type: Provide pre-printed, permanent adhesive, color coded, pressure sensitive, vinyl markers conforming to ANSI A13.1. This style marker shall be applied to all uninsulated piping; insulated piping 2-1/2" and larger.
- C. Flow Direction: Provide flow directional arrows either as part of markers, or separately attached to pipes.

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2.4 PAINTED IDENTIFICATION MATERIALS

- A. Piping and Equipment Systems: Continuous color coded painting of piping and equipment shall be provided in all mechanical rooms in compliance with ANSI A13.1.

2.5 UNDERGROUND-TYPE PLASTIC LINE MARKER

- A. General: Manufacturer's standard permanent, bright-colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6" (150 mm) wide x 4 mils thick. Provide tape with printing which most accurately indicates type of service of buried pipe.

1. Provide multi-ply tape consisting of solid aluminum foil core between two layers of plastic tape.

2.6 VALVE TAGS

- A. Brass Valve Tags: Provide 19-gage (1.2 mm) polished brass valve tags with stamp-engraved piping system abbreviation in 1/4" (6 mm) high letters and sequenced valve numbers 1/2" (13 mm) high, and with 5/32" (4 mm) hole for fastener.

1. Provide 1-1/2" (40 mm) diameter tags, except as otherwise indicated.

- B. Valve Tag Fasteners: Provide manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.

2.7 VALVE SCHEDULE FRAMES

- A. General: For each page of valve schedule, provide glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with lexan.

1. Locate one schedule where directed. Provide second schedule to Owner framed in rigid plastic frame with rigid plastic glazing.

2.8 ENGRAVED PLASTIC-LAMINATE SIGNS

- A. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in the sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black with white core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.

1. Thickness: 1/16" (1.6 mm) for units up to 20 sq. in. (12900 mm²) or 8" (200 mm) length; 1/8" for larger units.

- B. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive

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- where screws cannot or should not penetrate the substrate.
- C. Duty: Accident-prevention tags with appropriate wording including large-size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).
- 2.9 CEILING IDENTIFICATION TAGS**
- A. Laminated plastic with adhesive back, engraved black letters on white background, minimum 0.5 inch (15 mm) wide and length as required for 0.375 inch (10 mm) high letters for name of concealed device and number. Tags shall be provided for valves and all other concealed HVAC equipment.
- 2.10 PLASTIC EQUIPMENT MARKERS**
- A. General: Provide manufacturer's standard laminated plastic, color coded equipment markers.
- B. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
1. Name and schedule number
 2. Equipment service
- 2.11 LETTERING AND GRAPHICS**
- A. General: Coordinate names, abbreviations and other designations used in plumbing identification work with corresponding designations shown on plans. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of plumbing systems and equipment.
- PART 3 - EXECUTION**
- 3.1 GENERAL INSTALLATION REQUIREMENTS**
- A. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.
- 3.2 PIPING SYSTEM IDENTIFICATION**
- A. General: Install pipe markers on each system indicated to receive identification, and include arrows to show normal direction of flow.

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- B. Locate pipe markers as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) exterior non-concealed, locations, and concealed gas piping.
1. Near each valve and control device.
 2. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
 3. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.
 4. At access doors, manholes and similar access points which permit view of concealed piping.
 5. Near major equipment items and other points of origination and termination.
 6. Spaced intermediately at maximum spacing of 25 feet (7500 mm) along each piping run.
 - a. Space fire main, standpipe, and fire sprinkler main markers at intervals not exceeding 10' (3 m) on straight pipe runs unless pipe is painted red throughout.

3.3 UNDERGROUND PIPING IDENTIFICATION

- A. General: During back-filling/top-soiling of each exterior underground piping system, install continuous underground-type plastic line marker, located directly over buried line at 6" to 8" (150 to 200 mm) below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 16" (400 mm), install single line marker.

3.4 VALVE IDENTIFICATION

- A. General: Provide valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory fabricated equipment units, plumbing fixture faucets, convenience and lawn-watering hose bibs, shut-off valves at plumbing fixtures, and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.
1. Tagging Schedule: Comply with requirements of "Valve Schedule" of this section.
 2. Fire protection valves (shutoff, test, drain, etc. shall be labeled with a rigid plastic identification sign, secured with corrosion-resistant wire or chain, per NFPA 13.

3.5 PLUMBING EQUIPMENT IDENTIFICATION

- A. General: Install engraved plastic laminate sign on or near each major item of plumbing

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equipment and each operational device, as specified herein if not otherwise specified for each item or device. Provide signs for the following general categories of equipment and operational devices:

1. Pumps and similar motor driven units.
 2. Fire protection valves, as hereinbefore specified.
- B. Lettering Size: Minimum 1/4" (6 mm) lettering for name of unit where viewing distance is less than 2'- 0" (600 mm-0 mm), 1/2" (13 mm) high for distances up to 6'- 0" (1800 mm-0 mm), and proportionately larger lettering for greater distances. Provide secondary lettering 2/3 to 3/4 of size of principal lettering.
- C. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

3.6 ADJUSTING AND CLEANING

- A. Adjusting: Relocate any plumbing identification device which has become visually blocked by work of this division or other divisions.
- B. Cleaning: Clean face of identification devices, and glass frames of valve charts.

3.7 EXTRA STOCK

- A. Furnish minimum of 5% extra stock of each plumbing identification material required, including additional numbered valve tags (not less than 3) for each piping system, additional piping system identification markers, and additional plastic laminate engraving blanks of assorted sizes.

3.8 IDENTIFICATION SCHEDULE

<u>SERVICE</u>	<u>DESIGNATION</u>
Cold Water	CW
Hot Water	HW
Fire Protection	FIRE
Sprinkler	SPKR
Sanitary Sewer	SAN
Vent	VENT

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Storm Water	SW
Air Conditioning Drain	A/C COND
Pumped Discharge	PD

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SECTION 220700 - PLUMBING INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of mechanical insulation required by this section is indicated on drawings and schedules, and by requirements of this section.
- B. Types of mechanical insulation specified in this section include the following:
 - 1. Piping System Insulation:
 - a. Fiberglass
 - b. Flexible Elastomeric
 - 2. Equipment Insulation:
 - a. Fiberglass
 - b. Flexible Elastomeric
- C. Refer to all other Division-22 sections.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of mechanical insulation products, of types and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Installer's Qualifications: Insulation installer shall be an independent sub-contractor (i.e. not the mechanical or plumbing contractor). Firms shall have at least five (5) years successful installation experience on projects with mechanical insulations similar to that required for this project. Provide installer's certification by the manufacturer's training program. .
- C. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, k-value, thickness, and furnished accessories, and intended use for each mechanical system requiring insulation.

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- B. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product data in maintenance manual.
- C. Installer's Qualifications: Provide qualifications on each installer indicating experience (i.e. number of years and project samples) and all pertinent certifications.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.
- B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work, shall be limited to the following:
 1. Owens Corning
 2. Johns Manville
 3. Certainteed
 4. Armacell
 5. Knauf
 6. Aeroflex

2.2 PIPE INSULATION MATERIALS

- A. Fiberglass Pipe Insulation: ASTM C 547-00, Type 1 (up to 850°F) (up to 454°C), maximum k-value of 0.23 BTU-in/hr-ft²-deg F at a mean temperature of 75°F.
- B. Flexible Elastomeric Pipe Insulation: ASTM C 534, Type I (-40°F to 200°F) (-40°C to 93°C), maximum k-value of 0.25 BTU-in/hr-ft²-deg F at a mean temperature of 75°F.
- C. Jackets for Piping Insulation: Jacket assembly shall be ASTM C 1136, Type I with vapor retarder (0.02 perms).
 1. Encase pipe fittings insulation with one-piece premolded PVC fitting covers, fastened as per manufacturer's recommendations.
 2. Encase exterior piping insulation with 26 gauge embossed aluminum jacket with

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- weather-proof construction.
- D. Bands, Wires and Cement: As recommended by insulation manufacturer for applications indicated.
 - E. Adhesives, Sealer, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.
- B. Only install mechanical insulation on systems while not in operation.

3.2 PLUMBING PIPING SYSTEM INSULATION

- A. Insulation Omitted: Omit insulation on chrome-plated exposed piping (except for handicapped fixtures), fire protection piping, preinsulated equipment and air conditioning condensate drain piping in mechanical rooms and/or on roof.

- B. Cold Piping:

1. Application Requirements: Insulate the following cold plumbing piping systems:
 - a. Potable cold water piping.
 - b. Interior above-ground horizontal storm water piping and roof drain sumps.
 - c. Interior above-ground horizontal sanitary piping.
 - d. Plumbing vents within 6 linear feet (1800 mm) of roof outlet.
 - e. Air conditioning condensate drain piping.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

- a. Fiberglass: 1" (25 mm) thickness.
- b. Flexible Elastomeric: 1/2" (13 mm) thickness.

- C. Hot Piping:

1. Application Requirements: Insulate the following hot plumbing piping systems:
 - a. Potable hot water piping.

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- b. Potable hot water recirculating piping.
2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:
 - a. Fiberglass: 1" (25 mm) thick for pipe sizes up to 1" (25 mm). 1-1/2" (40 mm) thick for 1-1/4" (32 mm) and 1-1/2" (40 mm) pipe, and 2" (50 mm) thick for pipe sizes 2" (50 mm) and larger. Note: Insulation provided for domestic hot water applications shall have a minimum R-value of 6.0.

3.3 INSTALLATION OF PIPING INSULATION

- A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.
 1. Insulation materials shall not be applied until systems have been witnessed, documented, and submitted to meet pressure testing requirements indicated throughout these specifications.
- B. Install insulation on pipe systems subsequent to installation of heat tracing, 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 single cut piece to complete run. Do not use cut pieces or scraps abutting each other.
- D. Clean and dry surfaces prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
- E. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage. Staples shall not be used.
- F. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Provide factory molded insulation or pre-fabricated fittings for all valves, fittings, unions, etc. Valve handles must be extended by the mechanical contractor to accommodate the insulation without reducing the thickness or integrity of the valve insulation.
- G. All water test ports shall be accessible from the insulation. In addition, water flow measuring stations require access from insulation to verify sizes and model.
- H. Extend piping insulation without interruption through pipe hangers, walls, floors and similar piping penetrations, except where otherwise indicated.
- I. Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply 3" (75 mm) wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3" (75 mm) wide vapor barrier tape or band. If using pipe hangers, follow manufacturer's instructions for installation.

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- J. All exposed pipe insulation, including fittings, above 8'- 0" (2400 mm-0 mm) of finished floor shall have 8 oz. (227 g) fire retardant canvas cover neatly cut and parted seams shall be sealed.
- K. All exposed pipe insulation, including fittings, within 8' - 0" (2400 mm-0 mm) of finished floor or within a stairwell, shall be provided with aluminum or PVC protective covers. All edges shall be hemmed and all seams shall be concealed.
- L. All exterior piping shall be provided with an embossed aluminum jacket.
- M. For all insulated piping 2-1/2" (63 mm) and larger, provide insulated pipe saddles as follows:
 - 1. For domestic hot and cold water piping (up to 250°F), provide the following:
 - a. Minimum 3.75pcf, non-compressive, rigid, phenolic foam insulation. Fire and smoke rating shall be 25/50 or below per ASTM 84.
 - b. For cold applications below 75°F (24°C) a zero permeability, abuse resistant, vapor barrier shall be provided with matching butt strips. Apply a full coating of butyl joint sealant in addition to the butt strips for a completely sealed system.
 - c. The phenolic foam system shall have a K factor of 0.16 at a mean temperature for 75°F (24°C) and comply with ASTM Standard C1126.
 - d. Provide visible inspection sticker at the bottom of each saddle.
 - e. Pipe insulation saddles shall be Tru-Balance CoolDry Saddles as manufactured by Buckaroos, Inc. or equivalent.
 - f. Armacell Armafix Pipe Hangers may be used for cold water piping with flexible elastomeric insulation.

3.4 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division-22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping installer for piping insulation application and equipment installer for equipment insulation application. Before preparing piping shop drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

3.5 SCHEDULING

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

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3.6 EXISTING INSULATION REPAIR/REPLACEMENT

- A. Repair damaged sections of existing mechanical and plumbing insulation, either previously damaged or damaged during this construction period. Insulation shall be as specified herein.
- B. Provide new insulation on existing mechanical and plumbing piping where existing insulation has been removed due to damage, repair or abatement of existing hazardous materials.

3.7 PROTECTION AND REPLACEMENT

- A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
- B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION 220700

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of domestic water piping systems work is indicated on drawings and schedules, and by requirements of this section.
- B. Applications for domestic water piping systems include the following:
 - 1. Domestic cold-water piping
 - 2. Domestic hot-water piping
 - 3. Domestic recirculating-water piping
- C. Refer to appropriate Division-22 sections for insulation required in connection with domestic water piping; not work of this section.
- D. Refer to appropriate Division-02 sections for trenching and backfill required in conjunction with exterior water piping; not work of this section.
- E. Trenching and backfill required in conjunction with domestic water piping inside of building foundations is specified in applicable Division-02 and Division-22 sections, and is included as work of this section.
- F. Refer to other Division-22 sections for water treatment, (sterilization) not work of this section.

1.2 QUALITY ASSURANCE

- A. Qualification of Installers: The entire system shall be installed by trained workmen skilled in the installation of such systems.
- B. Plumbing Code Compliance: Comply with applicable portions of International Plumbing Code and all other applicable codes and/or Owner's requirements pertaining to plumbing materials, construction and installation of products.
- C. ANSI and ASTM Compliance: Comply with applicable standards pertaining to products and installation of domestic water piping systems.
- D. Lead Free Compliance: All components associated with potable water systems (including, but not limited to, valves, end use devices/fixtures, pipe, pipe fittings, solder/flux, etc.) shall be "lead-free" in accordance with all local, state and federal codes, as well as NSF/ANSI 372 (NSF 61-G).
- E. NSF Standard 14 Compliance: Plastic Piping components and related materials.

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1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's data for domestic water piping systems, materials and products.
- B. Shop Drawings: Submit scaled layout drawings as required by Division-22 Section "Basic Plumbing Requirements".

PART 2 - PRODUCTS

2.1 DOMESTIC WATER PIPING MATERIALS AND PRODUCTS

- A. General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, temperature ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in domestic water piping systems. Where more than one type of materials or products is indicated, selection is Installer's option.

2.2 BASIC IDENTIFICATION

- A. General: Provide identification complying with Division-22 Section "Identification for Plumbing Piping and Equipment".

2.3 BASIC PIPE, TUBE, AND FITTINGS

- A. General: Provide pipe, tube, and fittings complying with Division-22 Section "Pipe, Tube, and Fittings for Plumbing Systems", in accordance with the following listing:
- B. Interior Domestic Hot Water Piping:

1. Tube Size 2" (50 mm) and Smaller: Copper tube.

- a. Wall Thickness: Type L, hard-drawn temper.
- b. Fittings: Wrought-copper, solder-joints.
- c.

2. Pipe Size 2-1/2" (65 mm) and Larger: Copper pipe.

- a. Wall Thickness: Type L, hard-drawn temper.
- b. Fittings: Wrought-copper, solder joints.

- C. Interior Domestic Cold Water Piping:

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1. Tube Size 2" (50 mm) and Smaller: Copper tube.
 - a. Wall Thickness: Type L, hard-drawn temper.
 - b. Fittings: Wrought-copper, solder-joints.
 2. Pipe Size 2-1/2" (65 mm) and Larger: Copper pipe.
 - a. Wall Thickness: Type L, hard-drawn temper.
 - b. Fittings: Wrought-copper, solder joints.
- D. Below Grade Cold Water Piping:
1. Tube Size 2" (50 mm) and Smaller: Copper tube.
 - a. Wall Thickness: Type K, soft-annealed temper.
 - b. Fittings: Wrought-copper, solder-joints.

2.4 BASIC PIPING SPECIALTIES

- A. General: Provide piping specialties complying with Division-22 Section "Piping Specialties for Plumbing Systems", in accordance with the following listing:
1. Pipe escutcheons
 2. Low-pressure Y-type pipeline strainers
 3. Dielectric fittings
 4. Drip pans
 5. Pipe sleeves
 6. Sleeve seals

2.5 SPECIAL PIPING SPECIALTIES

- A. Water Hammer Arresters: Provide bellows type water hammer arresters, stainless steel casing and bellows, pressure rated for 250 psi (1725 kPa), tested and certified in accordance with PDI Standard WH-201.
- B. Hose Connection Vacuum Breakers: Provide hose connection vacuum breakers where indicated for back-siphonage protection.
1. Brass construction, suitable for indoor or outdoor use (maximum pressure 125 psi) (maximum pressure 865 kPa).
 2. Inlet shall be 3/4" (20 mm) standard female hose thread; outlets shall be 3/4" (20

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mm) male hose thread.

3. Provide non-removable feature to prevent unauthorized removal from pipe system or sill cock.

2.6 BASIC SUPPORTS AND ANCHORS

- A. General: Provide supports, anchors, and seals complying with Division-22 Section "Hangers and Supports for Plumbing Piping and Equipment", in accordance with the following listing:

1. Adjustable steel clevises, adjustable roller hangers, and adjustable pipe roll stands for horizontal piping hangers and supports.
2. Two-bolt riser clamps for vertical piping supports.
3. Concrete inserts, C-clamps, and steel brackets for building attachments.
4. Protection saddles for insulated piping support in hangers.
5. Copper flashings for piping penetrations.

2.7 BASIC VALVES

- A. General: Provide valves complying with Division-22 Section "Valves for Plumbing Piping", in accordance with the following listing:

1. Sectional Valves:
 - a. 2" (50 mm) and Smaller: Ball Valves.
 - b. 2-1/2" (65 mm) and Larger: Butterfly Valves.
2. Shutoff Valves:
 - a. 2" (50 mm) and Smaller: Ball Valves.
 - b. 2-1/2" (65 mm) and Larger: Butterfly Valves.
3. Drain Valves:
 - a. 2" (50 mm) and Smaller: Ball Valves.
4. Check Valves:
 - a. All Sizes: Swing Check Valves.

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2.8 SPECIAL VALVES

- A. General: Special valves required for domestic water piping systems include the following types:
1. Balance Cocks:
 - a. Soldered Ends 2" (50 mm) and Smaller: Class 125, bronze body, bronze plug, screw driver operated, straight or angle pattern.
 2. Hose Bibb:
 - a. Soldered End: Bronze body, renewable composition disc, wheel handle, 3/4" (20 mm) solder inlet, 3/4" (20 mm) hose outlet with integral vacuum breaker.
 3. Hydrants:
 - a. Recessed Non-Freeze Wall Hydrants: Cast-bronze box hydrant, polished bronze face plate, tee handle key, bronze casing, length to suit wall thickness, vacuum breaker, hinged locking cover, 3/4" (20 mm) inlet, hose outlet.

2.9 PRESSURE REGULATING VALVES

- A. General: Provide pressure regulating valves, single seated, direct operated type, bronze body, integral strainer, complying with requirements of ANSI/ASSE Standard 1003. Size for maximum flow rate and inlet and outlet pressures indicated on drawings.

2.10 BASIC EXPANSION COMPENSATION

- A. General: Provide expansion compensation products complying with Division-22 Section "Expansion Compensation for Plumbing Piping", in accordance with the following listing:
1. Expansion compensators for hot water piping.
 2. Pipe alignment guides.

2.11 BASIC METERS AND GAUGES

- A. General: Provide meters and gauges complying with Division-22 Section "Meters and Gauges for Plumbing Piping".

PART 3 - EXECUTION

3.1 INSTALLATION OF BASIC IDENTIFICATION

- A. General: Install mechanical identification in accordance with Division-22 Section "Identification for Plumbing Piping and Equipment".

3.2 INSTALLATION OF DOMESTIC WATER DISTRIBUTION PIPING

- A. General: Install water distribution piping in accordance with Division-22 Section "Pipe, Tube, and Fittings for Plumbing Systems".

3.3 INSTALLATION OF PIPING SPECIALTIES

- A. Install piping specialties in accordance with Division-22 Section "Piping Specialties for Plumbing Systems".
- B. Water Hammer Arresters: Install in upright position, in locations and of sizes in accordance with PDI Standard WH-201, and elsewhere as indicated.

3.4 INSTALLATION OF SUPPORTS, ANCHORS, AND SEALS

- A. Install supports, anchors, and seals in accordance with Division-22 Section "Hangers and Supports for Plumbing Piping and Equipment".

3.5 INSTALLATION OF VALVES

- A. Install valves in accordance with Division-22 Section "Valves for Plumbing Piping".
- B. Sectional Valves: Install on each branch and riser, close to main, where branch or riser serves two (2) or more plumbing fixtures or equipment connections, and elsewhere as indicated.
- C. Shutoff Valves: Install on inlet of each plumbing equipment item, and on inlet of each plumbing fixture, and elsewhere as indicated.
- D. Drain Valves: Install on each plumbing equipment item located to completely drain equipment for service or repair. Install at base of each riser, at base of each rise or drop in piping system, and elsewhere where indicated or required to completely drain domestic water piping system.
- E. Check Valves: Install on discharge side of each pump, and elsewhere as indicated.
- F. Balance Cocks: Install in each hot water recirculating loop, and elsewhere as indicated.

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- G. Hose Bibbs: Install where indicated, with vacuum breaker.
- H. Hydrants: Installed where indicated, in accordance with manufacturer's installation instructions.

3.6 INSTALLATION OF PRESSURE REGULATING VALVES

- A. Install pressure regulating valves where required to reduce the pressure below the code allowable pressure. Provide inlet and outlet shutoff valves, and globe valve bypass. Provide pressure gage on valve inlet outlet.

3.7 INSTALLATION OF EXPANSION COMPENSATION PRODUCTS

- A. Install expansion compensation products in accordance with Division-22 Section "Expansion Compensation for Plumbing Piping".

3.8 INSTALLATION OF METERS AND GAUGES

- A. Install meters and gauges in accordance with Division-22 Section "Meters and Gauges for Plumbing Piping".

3.9 EQUIPMENT CONNECTIONS

- A. Piping Runouts to Fixtures: Provide hot and cold water piping runouts of sizes indicated, but in no case smaller than required by International Plumbing Code.
- B. Mechanical Equipment Connections: Connect hot and cold water piping system to mechanical equipment as indicated, and comply with equipment manufacturer's installation instructions. Provide shutoff valve and union for each connection, provide drain valve on drain connection.

3.10 SPARE PARTS

- A. Furnish to the Owner, with receipt, one valve key for each key operated hydrant, bibb, or faucet installed.

END OF SECTION 221116

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SECTION 221123 - PLUMBING PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of plumbing pumps work required by this section is indicated on drawings and schedules, and by requirements of this section.
- B. Types of pumps specified in this section include the following:
 - 1. Elevator Sump Pumps
- C. Refer to other Division-22 sections for insulation of pump housings; not work of this section.
- D. Refer to other Division-22 sections for vibration control of plumbing pumps; not work of this section.
- E. Provide the following electrical work as work of this section, complying with requirements of Division-26 sections:
 - 1. Control wiring between field-installed controls, indicating devices, and pump control panels.

1.2 QUALITY ASSURANCE

A. Codes and Standards:

- 1. HI Compliance: Design, manufacture, and install plumbing pumps in accordance with HI "Hydraulic Institute Standards".
- 2. UL Compliance: Design, manufacture, and install plumbing pumps in accordance with UL 778 "Motor Operated Water Pumps".
- 3. UL and NEMA Compliance: Provide electric motors and components which are listed and labeled by Underwriters Laboratories and comply with NEMA standards.
- 4. SSPMA Compliance: Test and rate sump and sewage pumps in accordance with Sump and Sewage Pump Manufacturer's Association (SSPMA) and provide certified rating seal.
- 5. Lead Free Compliance: All components associated with potable water systems (including, but not limited to, valves, end use devices/fixtures, pipe, pipe fittings, solder/flux, etc.) shall be "lead-free" in accordance with all local, state and federal codes, as well as NSF/ANSI 372 (NSF 61-G).

- B. Certification, Pump Performance: Provide pumps whose performances, under specified

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operating conditions, are certified by manufacturer.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's pump specifications, installation and start-up instructions, and current accurate pump characteristic performance curves with selection points clearly indicated.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.
- C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to plumbing pumps. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- D. Maintenance Data: Submit maintenance data and spare parts lists for each type of pump, control, and accessory; including "troubleshooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Handle plumbing pumps and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged plumbing pumps or components; replace with new.
- B. Store plumbing pumps and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.
- C. Comply with Manufacturer's rigging and installation instructions for unloading plumbing pumps, and moving them to final location.

PART 2 - PRODUCTS

2.1 PUMPS

- A. General: Provide factory-tested pumps, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment. Type, size, and capacity of each pump are listed in pump schedule. Provide pumps of same type by same manufacturer.

2.2 ELEVATOR SUMP PUMPS

- A. General: Provide sump pumps in all elevator pits with the capacities as scheduled.
- B. Type: Submersible sump pump with a stainless steel oil sensor probe mounted on the pump, 2" discharge, double mechanical seal, cast iron impeller with check valve.

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- C. Control Panel: Provide control panel in a NEMA 4X fiberglass enclosure with visual and audible alarm, auxiliary contact, overcurrent relay, terminal board, RMS relay, magnetic contactor, alarm silence, pump overload light and horn.
- D. Provide junction box with multi-pin connector and power cord of length as required to connect to control panel. Coordinate power cord in conduit with Electrical Division.
- E. Provide Stancor elevator pit sump pump with "Oil Minder" control system or equivalent.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which plumbing pumps are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF PUMPS

- A. General: Install plumbing pumps where indicated, in accordance with manufacturer's published installation instructions, complying with recognized industry practices to ensure that plumbing pumps comply with requirements and serve intended purposes.
- B. Access: Provide access space around plumbing pumps for service as indicated, but in no case less than that recommended by manufacturer.
- C. Pits: Refer to Architectural Division for concrete work; not work of this section. Set cover over pit, fasten to top flange of basin. Install so cover is flush with finished floor.
- D. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
- E. Piping Connections: Refer to Division-22 plumbing piping sections. Provide piping, valves, accessories, gages, supports, and flexible connections as indicated.

3.3 ADJUSTING AND CLEANING

- A. Alignment: Check alignment, and where necessary, realign shafts of motors and pumps within recommended tolerances by manufacturer, and in presence of manufacturer's service representative.
- B. Start-up: Lubricate pumps before start-up. Start-up in accordance with manufacturer's instructions.

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- C. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION 221123

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SECTION 221316 - SOIL, WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of soil and waste piping system work is indicated on drawings and schedules, and by requirements of this section.
- B. Applications for soil and waste piping systems include the following:
 - 1. Aboveground soil, waste and vent piping within buildings including soil stacks, vent stacks, horizontal branches, traps, and connections to fixtures and drains.
 - 2. Underground building drain piping including mains, branches, traps, connections to fixtures and drains, and connections to stacks, terminating at connection to sanitary sewers five feet outside of foundation wall.
- C. Exterior sanitary sewer system is specified in applicable Division-02 sections, and is included as work of this section.
- D. Refer to appropriate Division-22 sections for insulation required in connection with soil and waste piping; not work of this section.
- E. Trenching and backfilling required in conjunction with underground building drain piping is specified in applicable Division-22 sections, and is included as work of this section.

1.2 QUALITY ASSURANCE

- A. Specimen Joints: Before commencing pipe laying, Contractor shall form specimen joints to demonstrate that materials and methods employed will result in watertight joints.
- B. Qualification of Installers: The entire system shall be installed by trained workmen skilled in the installation of such systems for a minimum of five (5) years.
- C. Plumbing Code Compliance: Comply with applicable portions of International Plumbing Code pertaining to plumbing materials, construction and installation of products.
- D. ANSI Compliance: Comply with applicable American National Standards pertaining to products and installation of soil and waste piping systems.
- E. PDI Compliance: Comply with applicable Plumbing and Drainage Institute Standards pertaining to products and installation of soil and waste piping systems.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's data for soil and waste piping systems materials

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- and products.
- B. Shop Drawings: Submit scaled layout drawings of soil and waste pipe and fittings showing interface and spatial relationship between piping, ductwork and proximate equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering cleanouts, drains and valves which may be incorporated in the Work include the following:
1. Josam
 2. J. R. Smith
 3. Zurn
 4. Mifab
 5. Wade
 6. Watts Drainage

2.2 SOIL, WASTE AND VENT PIPING MATERIALS AND PRODUCTS

- A. General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in soil and waste piping systems. Where more than one (1) type of materials or products is indicated, selection is Installer's option.

2.3 BASIC IDENTIFICATION

- A. General: Provide identification complying with Division-22 section, "Identification for Plumbing Piping and Equipment".

2.4 BASIC PIPE, TUBE, AND FITTINGS

- A. General: Provide pipe, tube, and fittings complying with Division-22 section "Pipe, Tube, and Fittings for Plumbing Systems", in accordance with the following listing:
- B. Above Ground Piping Within Buildings:

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1. Tube Size 8" (200 mm) and Smaller: Copper tube.
 - a. Wall Thickness: Type DWV.
 - b. Fittings: Cast-bronze, drainage pattern, solder-joint.
 2. Pipe Size 15" (400 mm) and Smaller: Cast-iron hub-and-spigot soil pipe.
 - a. Pipe and fittings to be service weight and shall comply with ASTM A 74 and bear the collective mark of the Cast Iron Soil Pipe Institute (CISPI).
 - b. Fittings: Compression gasket joints meeting the requirements of ASTM C-564, or lead and oakum joints.
- C. Underground Building Drain Piping:
1. Pipe Size 16" (400 mm) and Smaller: PVC Schedule 40.
 - a. Pipe and fittings shall be manufactured from virgin rigid polyvinyl chloride (PVC) compound with a cell class of 12454 per ASTM D 1784 and conform with NSF International Standard 14. Pipe shall be Schedule 40, solid wall, iron pipe size (IPS) conforming to ASTM D 1785 and ASTM D 2665. Molded fittings shall conform to ASTM D 2665. Fabricated fittings shall conform to ASTM F 1866. Installation to be in accordance with manufacturer's instructions and all applicable local code requirements. Buried Pipe to be installed in accordance with ASTM D 2321 and ASTM F 1668. Solvent cements shall conform to ASTM D 2564. Primers shall conform to ASTM F 656. Installation to be in accordance with manufacturer's instructions and all applicable local code requirements. Foam core, cellular core, etc. shall not be accepted.

2.5 BASIC PIPING SPECIALTIES

- A. General: Provide piping specialties complying with Division-22 section "Piping Specialties for Plumbing Systems", in accordance with the following listing:
1. Pipe Escutcheons
 2. Vandal-Proof Vent Caps
 3. Pipe Sleeves
 4. Sleeve Seals

2.6 SPECIAL PIPING SPECIALTIES

- A. Flashing Flanges: Cast-iron watertight stack or wall sleeve with membrane flashing ring. Provide underdeck clamp and sleeve length as required.
- B. Vent Flashing Sleeves: Cast-iron caulking type roof coupling for cast-iron stacks, cast-

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iron threaded type roof coupling for steel stacks.

2.7 SUPPORTS AND ANCHORS

- A. General: Provide supports and anchors complying with Division-22 sections in accordance with the following listing:
1. Adjustable steel clevises, steel pipe clamps, and pipe saddle supports for horizontal piping hangers and supports.
 2. Two-bolt riser clamps for vertical piping supports.
 3. Concrete inserts, C-clamps, and steel brackets for building attachments.
 4. Copper flashings for piping penetrations.

2.8 SPECIAL VALVES

- A. General: Special valves required for soil and waste piping systems include the following types:
1. Backwater Valves: Cast-iron body, bronze backwater valve assembly swing check type, with cleanout access cover. Provide ends to suit piping material; bolted cover.

2.9 CLEANOUTS

- A. General: Provide factory-fabricated drainage piping products of size and type indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements and governing regulations.
- B. Cleanouts in Piping: Cast-iron cleanout ferrule with bronze countersunk plug, suitable for no-hub applications.
- C. Cleanouts in finished walls and partitions shall be similar to cleanouts in piping. Provide round polished stainless steel wall access cover with screw. Finish as per Architect.
- D. Cleanouts in Tiled Floor: Cast-iron internal gasketed cleanout plug and adjustable housing with secured scoriated square satin Nickel Alloy top.
- E. Cleanouts in Non-Tiled Floor: Similar to tiled floor type with a secured scoriated round satin Nickel Alloy top.

2.10 FLOOR DRAINS

- A. General: Provide floor drains of size as indicated on drawings; and type, including features, as specified herein:
- B. Toilet Room Floor Drain: Cast-iron body and flashing collar, Nickel Alloy adjustable

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strainer head with secured square grate, with the following features:

1. Heel-proof grate.
 2. Provent Systems – Proset Trap Guard.
 3. Bottom outlet, no-hub for aboveground piping or, bottom outlet, hub and spigot for underground piping.
- C. Mechanical Room Floor Drain: Cast-iron body and flashing collar, heavy duty loose set grate (minimum 9" diameter) (minimum 225 mm diameter), with the following features:
1. Double drainage flange with weep holes.
 2. Sediment bucket.
 3. Adjustable extension.
 4. Provent Systems – Proset Trap Guard.
 5. Flat bottom strainer.
 6. Deep body.
 7. Bottom outlet, no-hub for aboveground piping or, bottom outlet, hub and spigot for underground piping.
 8. Provide funnels for drains receiving A/C condensate or elsewhere as indicated.
- D. General Purpose Floor Drain: Cast-iron body and flashing collar, Nickel Alloy adjustable strainer head with secured square grate, with the following features:
1. Sediment bucket.
 2. Heel-proof grate.
 3. Provent Systems – Proset Trap Guard.
 4. Bottom outlet, no-hub for aboveground piping or, bottom outlet hub and spigot for underground piping.
- E. Floor Sink: Rectangular cast-iron with deep acid resistant receptor, less grate with the following features:
1. Acid resistant sediment bucket.
 2. Provent Systems – Proset Trap Guard.

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PART 3 - EXECUTION

3.1 INSTALLATION OF BASIC IDENTIFICATION

- A. General: Install mechanical identification in accordance with Division-22 section "Identification for Plumbing Piping and Equipment".

3.2 INSTALLATION OF SOIL AND WASTE ABOVE GROUND PIPING

- A. General: Install soil and waste piping in accordance with Division-22 section "Pipe, Tube, and Fittings for Plumbing Systems", and with International Plumbing Code.

3.3 INSTALLATION OF BUILDING DRAIN PIPING

- A. General: Install underground building drains as indicated and in accordance with International Plumbing Code. Lay underground building drains beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install required gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements. Clean interior of piping of dirt and other superfluous material as work progresses. Maintain swab or drag in line and pull past each joint as it is completed. Temporarily cover end of uncompleted piping at end of day or whenever work stops.

1. Install soil and vent piping pitched to drain at minimum slope of 1/8" per foot (10 mm per meter) (1%). Where possible 1/4" per foot (20 mm per meter) (2%) shall be provided.

3.4 INSTALLATION OF PIPING SPECIALTIES

- A. Install piping specialties in accordance with Division-22 section "Piping Specialties for Plumbing Systems".

3.5 INSTALLATION OF SUPPORTS AND ANCHORS

- A. Install supports and anchors in accordance with Division-22 section "Hangers and Supports for Plumbing Piping and Equipment".

3.6 INSTALLATION OF SPECIAL VALVES

- A. Backwater Valves: Install in sanitary building drain piping serving fixtures located below curb line and as required by International Plumbing Code. For interior installation, provide cleanout cover flush to floor centered over backwater valve cover, and of adequate size to remove valve cover for service. Install in such a manner to provide

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maximum 1/4" (6 mm) clearance between flapper and seat for air circulation.

3.7 INSTALLATION OF DRAINAGE PIPING PRODUCTS

- A. Cleanouts: Install in sanitary above ground piping and sanitary building drain piping as indicated, as required by International Plumbing Code; and at each change in direction of piping greater than 45 degrees; at minimum intervals of 50 feet (15 m) for piping 4" (100 mm) and smaller and 75 feet (23 m) for larger piping; and at base of each vertical soil or waste stack. Install floor and wall cleanout covers for concealed piping, select type to match adjacent building finish.
- B. Flashing Flanges: Install flashing flange and clamping device with each stack and cleanout passing through waterproof membranes.
- C. Vent Flashing Sleeves: Install on stacks passing through roof, secure over stack flashing in accordance with manufacturer's instructions.

3.8 INSTALLATION OF FLOOR DRAINS

- A. General: Install floor drains in accordance with manufacturer's written instructions and in locations indicated.
 1. Coordinate with soil and waste piping as necessary to interface floor drains with drainage piping systems.
 2. Install floor drains at low points of surface areas to be drained, or as indicated. Set tops of drains flush with finished floor.
 3. Install drain flashing collar or flange so that no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes, where penetrated.
 4. Position drains so that they are accessible and easy to maintain.

3.9 EQUIPMENT CONNECTIONS

- A. Piping Runouts to Fixtures: Provide soil and waste piping runouts to plumbing fixtures and drains, with approved trap, of sizes indicated; but in no case smaller than required by International Plumbing Code.
 1. Locate piping runouts as close as possible to bottom of floor slab supporting fixtures or drains.

3.10 PIPING TESTS

- A. Test soil and waste piping system in accordance with requirements of Division-22 section "Pipe, Tube and Fittings for Plumbing Systems".

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END OF SECTION 221316

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SECTION 221413 - STORM WATER PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of storm water piping work is indicated on drawings and schedules, and by requirements of this section.
- B. Applications for storm water piping include the following:
 - 1. Conductor piping from roof drains and deck drains to storm water system.
 - 2. Storm water piping from conductor piping and area drains to storm sewers five feet outside of foundation wall.
 - 3. Air conditioning condensate piping.Sump pump discharge piping.
- C. Exterior storm water piping is specified in applicable Division-2 sections, and is included as work of this section.
- D. Refer to appropriate Division-22 sections for insulation required in conjunction with storm water piping; not work of this section.
- E. Trenching and backfill required in conjunction with storm building drain piping is specified in applicable Division-22 sections, and is included as work of this section.

1.2 QUALITY ASSURANCE

- A. Specimen Joints: Before commencing pipe laying, Contractor shall form specimen joints to demonstrate that materials and methods employed will result in watertight joints.
- B. Qualification of Installers: The entire system shall be installed by trained workmen skilled in the installation of such systems for a minimum of five (5) years.
- C. Plumbing Code Compliance: Comply with applicable portions of International Plumbing Code pertaining to plumbing materials, construction and installation of products.
- D. ANSI Compliance: Comply with applicable American National Standards pertaining to products and installation of soil, waste and storm water piping systems.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's data for storm water piping systems materials and products.
- B. Shop Drawings: Submit scaled layout drawings of installed storm water pipe and fittings

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showing interface and spatial relationship between piping and proximate equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering cleanouts, drains and valves which may be incorporated in the Work include the following:
1. Josam
 2. J. R. Smith
 3. Zurn
 4. Wade
 5. Mifab
 6. Watts Drainage

2.2 STORM WATER PIPING MATERIALS AND PRODUCTS

- A. General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in storm water piping systems. Where more than one type of materials or products is indicated, selection is Installer's option.

2.3 BASIC IDENTIFICATION

- A. General: Provide identification complying with Division-22 Section "Identification for Plumbing Piping and Equipment".

2.4 BASIC PIPE, TUBE AND FITTINGS

- A. General: Provide pipe, tube, and fittings complying with Division-22 Section "Pipe, Tube, and Fittings for Plumbing Systems", in accordance with the following listing:
- B. Above Ground Piping Within Buildings:
1. Pipe Size 15" (400 mm) and Smaller: Cast-iron hub-and-spigot soil pipe.
 - a. Pipe and fittings to be service weight and shall comply with ASTM A-74 and bear the collective mark of the Cast Iron Soil Pipe Institute (CISPI).

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- b. Fittings: Compression gasket joints meeting the requirements of ASTM C 564, or lead and oakum joints.

C. Underground Drain Piping:

1. Pipe Size 16" (400 mm) and Smaller: PVC Schedule 40.
 - a. Pipe and fittings shall be manufactured from virgin rigid polyvinyl chloride (PVC) compound with a cell class of 12454 per ASTM D 1784 and conform with NSF International Standard 14. Pipe shall be Schedule 40, solid wall, iron pipe size (IPS) conforming to ASTM D 1785 and ASTM D 2665. Molded fittings shall conform to ASTM D 2665. Fabricated fittings shall conform to ASTM F 1866. Installation to be in accordance with manufacturer's instructions and all applicable local code requirements. Buried Pipe to be installed in accordance with ASTM D 2321 and ASTM F 1668. Solvent cements shall conform to ASTM D 2564. Primers shall conform to ASTM F 656. Installation to be in accordance with manufacturer's instructions and all applicable local code requirements. Foam core, cellular core, etc. shall not be accepted.

D. Air Conditioning Condensate (above floor/roof):

1. 2" (50 mm) and Smaller: Copper.
 - a. Wall Thickness: Type M.
 - b. Fittings: Solder-joint.

E. Sump Pump Discharge:

1. 2" (50 mm) and Smaller: Copper.
 - a. Wall Thickness: Type M.
 - b. Fittings: Solder-joint.
2. All sizes: PVC Schedule 80.
 - a. Pipe and fittings shall be manufactured from virgin rigid polyvinyl chloride (PVC) compound with a cell class of 12454 per ASTM D 1784 and conform with NSF International Standard 14. Pipe shall be Schedule 80, solid wall, iron pipe size (IPS) conforming to ASTM D 1785. Molded fittings shall conform to ASTM D 2467. Installation to be in accordance with manufacturer's instructions and all applicable local code requirements. Buried Pipe to be installed in accordance with ASTM D 2774 and ASTM F 1668. Solvent cements and primers shall conform to ASTM D 2564. Installation to be in accordance with manufacturer's instructions and all applicable local code requirements.

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2.5 BASIC PIPING SPECIALTIES

- A. General: Provide piping specialties complying with Division-22 Section, "Piping Specialties for Plumbing Systems", in accordance with the following listing:
 - 1. Pipe Escutcheons
 - 2. Drip-Pans
 - 3. Pipe Sleeves
 - 4. Sleeve Seals

2.6 SUPPORTS AND ANCHORS

- A. General: Provide supports and anchors complying with Division-22 Section, "Hangers and Supports for Plumbing Piping and Equipment".

2.7 SPECIAL VALVES

- A. General: Special valves required for storm water piping systems include the following types:
 - 1. Backwater Valves: Cast-iron body, bronze backwater valve assembly swing check type, with cleanout access cover. Provide ends to suit piping material; bolted cover.

2.8 SPECIAL PIPING SPECIALTIES

- A. Flashing Flanges: Cast-iron watertight stack or wall sleeve with membrane flashing ring. Provide underdeck clamp and sleeve length as required.

2.9 CLEANOUTS

- A. General: Provide factory-fabricated cleanouts of size and type indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements and governing regulations.
- B. Cleanouts in Piping: Cast-iron cleanout ferrule with bronze countersunk plug, suitable for no-hub applications.
- C. Cleanouts in finished walls and partitions shall be similar to cleanouts in piping. Provide round polished stainless steel wall access cover with screw. Finish as per Architect.
- D. Cleanouts in Tiled Floor: Cast-iron internal gasketed cleanout plug and adjustable housing with secured scoriated square satin Nickel Alloy top.
- E. Cleanouts In Non-Tiled Floor: Similar to tiled floor type with a secured scoriated round satin Nickel Alloy top.

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2.10 ROOF DRAINS

- A. General: Provide roof drains of size as indicated on drawings; and type, including features, as specified herein:
1. Roof Drain: Cast-iron body and combined flashing collar, cast-iron dome, integral gravel stop with following features:
 - a. Underdeck clamp with support ring.
 - b. Fixed extension flange – adjustable extensions are not acceptable. Coordinate length of extension with roof thickness.
 - c. Large sump with anchor flange.
 - d. Vandal-proof dome.
 - e. Bottom outlet, no-hub.
 - f. Perforated gravel guard, on ballasted roofs
 - g. Internal overflow ring dam; coordinate height with structural engineer

PART 3 - EXECUTION

3.1 INSTALLATION OF BASIC IDENTIFICATION

- A. General: Install mechanical identification in accordance with Division-16 Section "Identification for Plumbing Piping and Equipment".

3.2 INSTALLATION OF STORM WATER PIPING ABOVE GROUND

- A. General: Install storm water piping in accordance with Division-22 Section, "Pipe, Tube, and Fittings for Plumbing Systems", and with International Plumbing Code.

3.3 INSTALLATION OF BUILDING DRAIN PIPING

- A. General: Install storm building drains as indicated and in accordance with International Plumbing Code. Lay storm building drains beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install required gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements. Clear interior of piping of dirt and other superfluous material as work progresses. Maintain swab or drag in line and pull past each joint as it is completed. Place plugs in ends of uncompleted piping at end of day or whenever work stops.
- B. Air conditioning (A/C) condensate piping shall be extended from all A/C condensate source equipment (air handling units, fan coil units, unit ventilators, split system A/C

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- units, etc.) and connected to the nearest storm water pipe/drain location. Size per manufacturer.
- C. Install storm water piping pitched to drain at minimum slope of 1/8" per foot (10 mm per meter) (1%). Where possible, 1/4" per foot (20 mm per meter) (2%) shall be provided.

3.4 INSTALLATION OF PIPING SPECIALTIES

- A. Install piping specialties in accordance with requirements of Division-22 Section, "Piping Specialties for Plumbing Systems".

3.5 INSTALLATION OF SUPPORTS AND ANCHORS

- A. Install supports and anchors in accordance with Division-22 Section, "Hangers and Supports for Plumbing Piping and Equipment".

3.6 INSTALLATION OF SPECIAL VALVES

- A. Backwater Valves: Install in storm water piping as indicated, and as required by International Plumbing Code. For interior installation, provide cleanout cover flush to floor centered over backwater valve cover, and of adequate size to remove valve cover for service. Install in such a manner to provide a maximum 1/4" (6 mm) clearance between flapper and seat for air circulation.

3.7 INSTALLATION OF DRAINAGE PIPING PRODUCTS

- A. Cleanouts: Install in conductor piping and storm building drain piping as indicated, as required by International Plumbing Code; at each change in direction of piping greater than 45 degrees; at minimum intervals of 50 feet (15 m) for piping 4" (100 mm) and smaller and 75 feet (23 m) for larger piping; and at base of each conductor. Install floor and wall cleanout covers for concealed piping, select type to match adjacent building finish.
- B. Flashing Flanges: Install flashing flange and clamping device with each cleanout passing through waterproof membrane.

3.8 INSTALLATION OF DRAINS

- A. General: Install drains in accordance with manufacturer's written instructions and in locations indicated.
- B. Coordinate with roofing as necessary to interface roof drains with roofing work.
- C. Coordinate with storm water piping as necessary to interface drains with drainage piping systems.
1. Install drains at low points of surface areas to be drained, or as indicated.

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2. Install drain flashing collar or flange so that no leakage occurs between drain and adjoining roofing. Maintain integrity of waterproof membranes, where penetrated.
- D. Position drains so that they are accessible and easy to maintain.

3.9 PIPING TESTS

- A. Test storm water piping system in accordance with requirements of Division-23 Section, "Testing, Adjusting and Balancing".

END OF SECTION 221413

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SECTION 224000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of plumbing fixture work required by this section is indicated on drawings and schedules, and by requirements of this section.
- B. Types of plumbing fixtures specified in this section include the following:
 - 1. Water Closets
 - 2. Urinals
 - 3. Lavatories
 - 4. Sinks
 - 5. Mop Basins
 - 6. Electric Water Coolers
 - 7. Showers
- C. Refer to Division-22 sections for potable water systems used in conjunction with plumbing fixtures; not work of this section.
- D. Refer to Division-22 sections for soil and waste systems used in conjunction with plumbing fixtures; not work of this section.
- E. Refer to Division-26 sections for field-installed electrical wiring required for water coolers and other plumbing fixtures; not work of this section.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of plumbing fixtures of type, style and configuration required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Codes and Standards:
 - 1. Plumbing Fixture Standards: Comply with applicable portions of International Plumbing Code pertaining to materials and installation of plumbing fixtures.
 - 2. ANSI Standards: Comply with applicable ANSI standards pertaining to plumbing fixtures and systems, and bath tub units.

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3. PDI Compliance: Comply with standards established by PDI pertaining to plumbing fixture supports.
4. Federal Standards: Comply with applicable FS WW-P-541-Series sections pertaining to plumbing fixtures.
5. NAHB Label: Provide fiberglass bath tub units and shower stalls which have been tested and labeled by NAHB Research Foundation Inc.
6. UL Compliance: Construct water coolers in accordance with UL Standards and provide UL listing and label.
7. ASHRAE Compliance: Test and rate water coolers in accordance with ASHRAE Standard 18 "Method of Testing for Rating Drinking Water Coolers with Self-Contained Mechanical Refrigeration Systems".
8. ARI Compliance: Construct and install water coolers in accordance with ARI Standard 1010 "Drinking-Fountains and Self-Contained Mechanically-Refrigerated Drinking-Water Coolers", and provide Certification Symbol.
9. ANSI Compliance: Construct and install barrier-free plumbing fixtures in accordance with ANSI Standard A117.1 "Specifications for Making Buildings and Facilities Accessible To and Usable By Physically Handicapped People".
 - a. Comply with Public Law 90-480, known as the Architectural Barriers Act of 1968.
10. ADA Compliance: Comply with provisions set forth in the "Americans with Disabilities Act Accessibility Guidelines."
11. Lead Free Compliance: All components associated with potable water systems (including, but not limited to, valves, end use devices/fixtures, pipe, pipe fittings, solder/flux, etc.) shall be "lead-free" in accordance with all local, state and federal codes, as well as NSF/ANSI 372 (NSF 61-G).

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, furnished specialties and accessories; and installation instructions.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, roughing-in requirements, required clearances, and methods of assembly of components and anchorages.
- C. Maintenance Data: Submit maintenance data and parts lists for each type of plumbing fixture and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, and shop drawings in maintenance manual.

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1.4 DELIVERY, STORAGE AND HANDLING

- A. Deliver plumbing fixtures individually wrapped in factory-fabricated containers.
- B. Handle plumbing fixtures carefully to prevent breakage, chipping and scoring fixture finish. Do not install damaged plumbing fixtures; replace and return damaged units to equipment manufacturer.

PART 2 - PRODUCTS

2.1 PLUMBING FIXTURES

- A. General: Provide factory-fabricated fixtures of type, style and material indicated. For each type of fixture unless otherwise noted, provide fixture manufacturer's standard trim, carrier, seats, and valves as indicated by their published product information; either as designed and constructed, or as recommended by manufacturer, and as required for complete installation.

Where more than one type is indicated, selection is Installer's option. All fixtures of same type must be furnished by single manufacturer. Where type is not otherwise indicated, provide fixtures complying with governing regulations.

WC-1- Water Closet - Flush Valve: Vitreous china, floor mounted toilet (1.6 gal/flush) (6.1 L/flush) with siphon jet action, elongated bowl with open front seat, 1-1/2" (40 mm) top spud and Sloan: Royal 111 flush valve. American Standard "Madera" or equivalent. Provide PVC Twist-N-Set toilet flange. Glued flanges are not acceptable.

WC-2 - Water Closet - Flush Valve - ADA Compliant: Vitreous china, floor mounted toilet (1.6 gal/flush) (6.1 L/flush) with siphon jet action, elongated bowl, with open front seat, 1-1/2" (40 mm) top spud and Sloan: Royal II #111 flush valve. Top of seat shall be 18" (450 mm) above finished floor. American Standard "Madera" or equivalent. Provide PVC Twist-N-Set toilet flange. Glued flanges are not acceptable.

WC-3 - Water Closet - Flush Valve: Vitreous china, wall mounted toilet (1.6 gal/flush) (6.1 L /flush) with siphon jet action, elongated bowl with open front seat, 1-1/2" (40 mm) top spud with Sloan: Royal II #111 flush valve and wall brackets. Mounting height shall be 15" (380 mm) to top of seat. American Standard "Afwall" water closet or equivalent.

WC-4- Water Closet - Flush Valve – ADA Compliant: Vitreous china, wall mounted toilet (1.6 gal/flush) (6.1 L /flush) with siphon jet action, elongated bowl with open front seat, 1-1/2" (40 mm) top spud with Sloan: Royal II #111 flush valve and wall brackets. Mounting height shall be 18" (450 mm) to top of seat. American Standard "Afwall" water closet or equivalent.

L-1 - Lavatory - Wall Mounted - ADA Compliant: 18" x 20" (450 mm x 500

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mm) vitreous china with front overflow, self-draining deck, floor mounted carrier, and 4" (100 mm) centers. Provide fittings 4" (100 mm) on center with 5" (130 mm) gooseneck spout, 4" (100 mm) wristblades with 0.5 gpm (.04 L/s) (max) aerator. Provide grid drain assembly, flexible supplies, tailpiece and cast brass P-trap. Lavatory shall be American Standard "Lucerne" or equivalent.

L-2 - Lavatory - Countertop: Self-rimming lavatory with front overflow, faucet ledge and 4" (100 mm) centers. Provide fittings 4" (100 mm) on center with 5" spout, 4" (100 mm) wristblades with 0.5 gpm (.04 L/s) (max) aerator. Provide grid drain assembly, flexible supplies, tail piece and cast brass P-trap. Lavatory shall be American Standard "Aqualyn" or equivalent.

S-1 - Single Compartment Countertop Sink (Workrooms, Teachers Lounge) – ADA Compliant: 25" x 21" (625 mm x 525 mm) 18-gauge (1.3 mm) stainless steel single compartment sink with 3 hole punch. Provide 8" (200 mm) gooseneck swing spout, 4" (100 mm) wristblade handle, 8" (200 mm) faucet centers, 1.0 gpm (.08 L/s) (max) non-aerating spray, rear center drain, chrome basket strainer, flexible supplies, stops, tailpiece, cast brass P-trap with cleanout and trap arm. Sink shall be Elkay "Lustertone" LRAD252165PD or equivalent. Faucet shall be Chicago 786-E26-5ABCP or equivalent. Fitted with:

Supplies and Stops: McGuire Manufacturing Co., Inc., 3/8-inch chrome plated brass stops with stuffing box, full turn brass stem, no plastic, cast brass nipples, cast brass elbow, cast brass reducer and flange with set screw.

Thermostatic Mixing Valve: Provide ASSE 1070 point-of-use thermostatic mixing valve, Lawler 570 or equivalent.

Trap: McGuire No. 8912 1-1/2 by 1-1/2-inch adjustable P-trap, cast body, cleanout plug, slip inlet tubing drain to wall, cast brass escutcheon and set screw.

S-2 – Scullery Sink with Sideboard (Concessions): One compartment 16 gauge type 300 stainless steel sink with 18 inch right drainboard, 9" high backsplash with 2 hole punch for faucet, center drain and stainless steel legs. Sink bowl dimensions – 18" x 24" x 14" deep and overall dimensions 38 ½" x 20-13/16" x 43-3/4". Faucet shall be chrome plated, wall mounted pre-rinse fitting with 8" adjustable centers and 12" L-type swing spout with vandal proof 2-3/8" lever handles. Pre-rinse valve shall flow 1.0 gpm @ 60 psi; pre-rinse hose shall be 44" flexible stainless steel with insulated handle and secured with pipe strap and hook assembly. Provide grid drain assembly, flexible supplies, tail piece and cast brass P-trap. Sink shall be Elkay Model 14-1C18X24-R-18X and faucet shall be Chicago Faucets Model 510-G613L12XKCAB. Fitted with:

Supplies and Stops: McGuire Manufacturing Co., Inc., 3/8-inch chrome plated brass stops with stuffing box, full turn brass stem, no plastic, cast

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brass nipples, cast brass elbow, cast brass reducer and flange with set screw.

Thermostatic Mixing Valve: Provide ASSE 1070 point-of-use thermostatic mixing valve, Lawler 570 or equivalent.

Trap: McGuire No. 8912 1-1/2 by 1-1/2-inch adjustable P-trap, cast body, cleanout plug, slip inlet tubing drain to wall, cast brass escutcheon and set screw.

S-3 – Single Compartment Countertop Sink with Bubbler and Eyewash (Health Room) – ADA Compliant: Elkay Lustertone DRKAD222060R, single compartment, 5-1/2-inch deep, counter mounted sink made from 18 gauge type 304 stainless steel, self- rimming, 22-inch length x 19-1/2-inch wide overall dimensions, 16-inch length x 13-1/2-inch width x 6-inch depth inside dimensions, faucet drilled 4-inch centers and bubbler drilled at right. Sink bowl with rear center drain opening is 3- ½-inch diameter with LK372, Type 316 stainless steel body with grid strainer. Fitted with:

Faucet with Integrated Eyewash: Speakman Model No. SEF-1800-CA, deck mounted hot and cold water sink faucet with independently operated integrated eyewash, polished chrome plated solid brass construction, 5-1/4-inch center-to-center gooseneck spout, vandal-resistant, polished chrome, ADA compliant, 4-inch metal wristblade handles with secured blue and red buttons, pull handle activator, aerated yellow plastic spray outlets with flip-top dust caps, 2.9 gpm at 30 psi. Provide ASSE 1071 thermostatic mixing valve for eyewash. Fitted with:

Bubbler: Chicago Faucet Model 748-665FHABCP vandal proof push button controlled, chrome plated body with ½-inch straight pipe threaded connection, no-lead, metering adjustable cycle time closure cartridge, built-in adjustable water volume control, Flexi-Guard Bubbler.

Supplies and Stops: McGuire Manufacturing Co., Inc., 3/8-inch chrome plated brass stops with stuffing box, full turn brass stem, no plastic, cast brass nipples, cast brass elbow, cast brass reducer and flange with set screw.

Thermostatic Mixing Valve: Provide ASSE 1070 point-of-use thermostatic mixing valve, Lawler 570 or equivalent.

Trap: McGuire No. 8912 1-1/2 by 1-1/2-inch adjustable P-trap, cast body, cleanout plug, slip inlet tubing drain to wall, cast brass escutcheon and set screw.

S-4 – Single Compartment Countertop Sink with Bubbler (Choral Room and Instrument Storage): Elkay Lustertone DRKR2220R, single compartment ADA accessible sink. 22-inches length by 19 1/2-inch width by 7-1/2-inch depth overall dimensions, 16-inch length by 13-1/2-inch width by 7-1/2-inch depth inside dimensions, 18 gauge, type 304 stainless steel, self-rimming satin finish with fully undercoated to dampen sound and prevent condensation. Three faucet holes on back ledge and

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bubbler hole drilled on right front, 3-1/2-inch drain outlet (off-centered rear) fitting with LK372, Type 316 stainless steel body with grid strainer. Fitted with:

Faucet: Chicago Faucets, Model Mo. 1100-GN2AE28-317ABCP, deck mounted hot and cold water sink faucet, polished chrome plated solid brass construction, 8-inch center- to-center rigid/swing field convertible gooseneck spout. 1.5 gpm spray outlet, vandal- resistant, polished chrome, spray outlet with key, ADA compliant, 4-inch metal wristblade handles with sixteen point tapered branch and secured blue and red buttons.

Bubbler: Chicago Faucet Model 748-665FHABCP vandal proof push button controlled, chrome plated body with ½-inch straight pipe threaded connection, no-lead, metering adjustable cycle time closure cartridge, built-in adjustable water volume control, Flexi-Guard Bubbler.

Supplies and Stops: McGuire Manufacturing Co., Inc., 3/8-inch chrome plated brass stops with stuffing box, full turn brass stem, no plastic, cast brass nipples, cast brass elbow, cast brass reducer and flange with set screw.

Trap: McGuire No. 8912 1-1/2 by 1-1/2-inch adjustable P-trap, cast body, cleanout plug, slip inlet tubing drain to wall, cast brass escutcheon and set screw.

US-1 - Utility Sink: Single compartment, molded polymer sink with 4 inch ledge and support legs and integrally molded drain. Provide 4" (100 mm) centerset, deck mounted faucet, chrome plated brass, swing hose connection with vacuum breaker/spout, supplies, stops and cast brass P-trap with cleanout. Sink shall be Fiat Model "SF-1-F" and faucet shall be Chicago Faucets 526-317ABCP or equivalent. Provide ASSE 1070 point-of-use thermostatic mixing valve, Lawler 570 or equivalent.

SH-1 – Shower – ADA Compliant: 36" x 36" (900 mm x 900 mm) precast terrazzo shower floor with coved corners sloping to integral stainless steel drain body, slip resistant, with galvanized tiling flanges on 3 sides. Polished terrazzo shall be constructed of marble chips cast in portland cement producing compression strength of 3000 psi (20400 kPa) or more. Provide pressure balancing shower valve with single lever control and flow control shower head.

Shower Fixture (Detachable, Wall Mounted, Concealed Supplies, Thermostatic Valve):

Shower Base: Acorn SBADA-3F. Provide Provent Systems Trap Guard drain insert.

Shower Installation: Wall mounted detachable spray assembly, 24-inch (600 mm) ADA wall bar, elevated vacuum breaker, supply elbow and flange

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and valve. All external trim, chrome plated metal.

Shower Head Assembly: Plastic shower head with flow control to limit discharge to 1.5 gpm, 5-foot (1.5 m) length of rubber lined CRS, chrome plated metal flexible and supply wall elbow. Design shower head to fit in palm of hand with on/off control with a non-positive shut-off. Provide CRS or chrome plated metal wall bar with an adjustable swivel hanger for shower head. Fasten wall bar securely to wall for hand support.

Valves: Thermostatic type T/P combination temperature and pressure balancing, with chrome plated metal lever type operating handle adjustable for rough-in variations and chrome plated metal or CRS face plate. Valve body shall be any suitable copper alloy. Internal parts shall be copper, nickel alloy, CRS or thermoplastic material. Valve inlet and outlet shall be 1/2-inch (13 mm) IPS.

Provide external screwdriver check stops, vacuum breaker and temperature limit stops. Set stops for a maximum temperature of 105 degrees F. All exposed fasteners shall be vandal resistant. Valve shall provide a minimum of 6 gpm at 45 psi (310 kPa) gage pressure drop.

EWC-1 - Electric Water Cooler with Bottle Filler – Bi-Level Wall Mounted - ADA Compliant – Non-Filtered: Basin shall be rectangular shaped, non-corrosive, stainless steel with satin finish, contour formed, rounded corners and edges. Bubbler shall be vandal resistant, chrome plated, non-removable, regulated and anti-squirt with integral hood with flush mounted chrome plated brass button. Bottle filler shall be hands free sensor operation, 1 gpm laminar flow with inlet strainer. Provide 3/8" (10 mm) supply, stops, P-trap and 1-1/4" (30 mm) O.D. tailpiece and carrier. Murdock A172.8-VR-BF12 Series or equivalent.

MB-1 - Mop Basin - Floor Mounted: One piece, white molded stone, 24" x 24" x 10" deep, factory installed stainless steel drain body with strainer, fitted with stainless steel wall guard, vinyl bumper guards, wall mounted faucet with vacuum breaker spout, mop hanger, and hose with bracket. Fiat model MSB-2424, Chicago model 540-LD8975WXFABCP or equivalent. Provide heavy gauge stainless steel wall guards.

IMC-1 – Ice Maker Connection Utility Box – Wall Mounted: 16 gauge (1.6 mm) stainless steel, overflow guard and plated quarter-turn ball valve with integral hammer arrester. Unit shall be fire rated Guy Gray FR1B12 Series.

- B. All plumbing fixtures indicated to be ADA compliant on the mechanical or architectural drawings shall comply with the "Americans with Disabilities Act Accessibility Guidelines". ADA compliant plumbing fixtures shall meet the latest ADA requirements and installation guidelines shall include, but not be limited to, the following:

Water Closets: Top of seat greater than 17 inches (425 mm) but not to exceed 19" (475 mm) above finished floor. Flush valve not to exceed 44" (1100 mm) above finished floor.

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Urinals: Top of rim shall not exceed 17" (425 mm) above finished floor. Flush valve not to exceed 44" (1100 mm) above finished floor.

Lavatories: Top of rim or counter shall not exceed 34" (850 mm) above finished floor. Faucets may be lever operated, push button or electronically controlled; however, the faucet must remain open for a minimum of 10 seconds. Faucets also must not require more than five pounds of force to activate the control, and the control must be operable without tight grasping, pinching or twisting of the wrist. Where piping is exposed beneath the lavatory, provide manufactured premolded insulated pipe for exposed hot water, cold water and sanitary drain piping; Lavguard or equivalent.

Water Coolers: Water spout height shall not exceed 36" (900 mm) above finished floor.

Showers: Controls must be located adjacent to the entrance and are required to be above 38" (950 mm) but no higher than 48" (1200 mm) from the floor. Shower sprayers must have both fixed and hand-held use capabilities, with a 60" (1500 mm) flexible hose. (A fixed head may be used in vandal-prone areas.) Controls require activation pressures not exceeding five pounds (34 kPa) of force nor requiring tight grasping, pinching or twisting of the wrist.

2.2 MATERIALS

- A. General: Unless otherwise specified, comply with applicable Federal Specification WW-P-541 Series sections pertaining to plumbing fixtures, fittings, trim, metals and finishes. Comply with requirements of WW-P-541 specification relative to quality of ware, glazing, enamel, composition and finish of metals, air gaps, and vacuum breakers, even though some plumbing fixtures specified in this section are not described in WW-P-541.
- B. Provide materials which have been selected for their surface flatness and smoothness. Exposed surfaces which exhibit pitting, seam marks, roller marks, foundry sand holes, stains, discoloration, or other surface imperfections on finished units are not acceptable.
- C. Where fittings, trim and accessories are exposed or semi-exposed, provide bright chrome-plated or polished stainless steel units. Provide copper or brass where not exposed.
- D. Stainless Steel Sheets: ASTM A 167, Type 302/304, hardest workable temper.
 - 1. Finish: No. 4, bright, directional polish on exposed surfaces.
- E. Steel Sheets for Baked Enamel Finish: ASTM A591, coating Class C, galvanized-bonderized.
- F. Steel Sheets for Porcelain Enamel Finish: ASTM A424, commercial quality, Type I.
- G. Galvanized Steel Sheet: ASTM A526, except ASTM A527 for extensive forming; ASTM A525, G90 zinc coating, chemical treatment.

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- H. Aluminum: ASTM B209/B221 sheet, plate and extrusions, as indicated; alloy, temper and finish as determined by manufacturer, except 0.40 mil natural anodized finish on exposed work unless another finish is indicated.
- I. Vitreous China: High quality, free from fire cracks, spots, blisters, pinholes and specks; glaze exposed surfaces, and test for crazing resistance in accordance with ASTM C 554.
- J. Synthetic Stone: High quality, free from defects, glaze on exposed surfaces, stain resistant.

2.3 PLUMBING FITTINGS, TRIM AND ACCESSORIES

- A. Water Outlets: At locations where water is supplied (by manual, automatic or remote control), provide commercial quality faucets, valves, or dispensing devices, of type and size indicated, and as required to operate as indicated. Include manual shutoff valves and connecting stem pipes to permit outlet servicing without shut-down of water supply piping systems.
 - 1. Vacuum Breakers: Provide with flush valves where required by governing regulations, including locations where water outlets are equipped for hose attachment.
- B. P-Traps: Include removable P-traps where drains are indicated for direct connection to drainage system.
- C. Provide cast-iron supports for fixtures of either graphitic gray iron, ductile iron, or malleable iron as required.
- D. Fixture Bolt Caps: Provide manufacturer's standard exposed fixture bolt caps finished to match fixture finish.
- E. Escutcheons: Where fixture supplies and drains penetrate walls in exposed locations, provide chrome-plated sheet steel escutcheons with friction clips.
- F. Aerators: Provide aerators of types approved by the Owner, and complying with flow constrictions, hereinbefore specified.
- G. Comply with additional fixture requirements contained in fixture schedule indicated on the Drawings.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine roughing-in work of potable water and waste piping systems to verify actual locations of piping connections prior to installing fixtures. Also examine floors and substrates, and conditions under which fixture work is to be accomplished. Correct any incorrect locations of piping, and other unsatisfactory conditions for installation of

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plumbing fixtures. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF PLUMBING FIXTURES

- A. General: Install plumbing fixtures of types indicated where shown and at indicated heights; in accordance with fixture manufacturer's written instructions, roughing-in drawings, and with recognized industry practices. Ensure that plumbing fixtures comply with requirements and serve intended purposes. Comply with applicable requirements of International Plumbing Code pertaining to installation of plumbing fixtures.
- B. Fasten plumbing fixtures securely to indicated supports or building structure; and ensure that fixtures are level and plumb. Secure plumbing supplies behind or within wall construction so as to be rigid, and not subject to pull or push movement.
- C. Protect installed fixtures from damage during remainder of construction period.

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation of plumbing fixtures and after units are water pressurized, test fixtures to demonstrate capability and compliance with requirements. When possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units and proceed with retesting.
- B. Inspect each installed unit for damage to finish. If feasible, restore and match finish to original at site; otherwise, remove fixture and replace with new unit. Feasibility and match to be judged by the Owner. Remove cracked or dented units and replace with new units.

3.4 ADJUSTING AND CLEANING

- A. Clean plumbing fixtures, trim, and strainers of dirt and debris upon completion of installation.
- B. Adjust water pressure at water coolers, faucets, shower valves, and flush valves to provide proper flow stream and specified gpm.
- C. Adjust or replace washers to prevent leaks at faucets and stops.

3.5 EXTRA STOCK

- A. General: Furnish special wrenches and other devices necessary for servicing plumbing fixtures and trim to the Owner with receipt. Furnish one (1) device for every ten (10) units.

END OF SECTION 224000

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SECTION 230100 - BASIC HVAC REQUIREMENTS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS

- A. Unless otherwise modified, provisions of General Conditions, Supplementary Conditions and Division-01 govern work under the Mechanical Divisions.
- B. Contract drawings for mechanical work are diagrammatic, intended to convey scope and general arrangement. Contractor shall review and coordinate routing of new work to clear existing piping, duct, electrical, structure, etc. at no cost to the Owner. All dimensions of existing conditions shall be considered approximate (for information only). All dimensions shall be verified prior to construction.
- C. Contract Document Interpretation/Discrepancies:
 - 1. Should the Contractor discover any discrepancies or omissions on the drawings or in the specifications, he shall notify the Architect/Engineer (A/E) of such conditions prior to the bid date. Otherwise, it will be understood that the drawings and specifications are clear as to what is intended and shall be as interpreted by the A/E.
 - 2. In addition, should any contradiction, ambiguity, inconsistency, discrepancy or conflict appear in or between any of the Contract Documents, the Contractor, shall, before proceeding with the work in question, notify the A/E and request an interpretation. In no case shall he proceed with the affected work until advised by the A/E.
 - 3. If the Contractor fails to make a request for interpretation of discrepancies or conflicts in the drawings or specifications, no excuse will be accepted for failure to carry out the work in a satisfactory manner, as interpreted by the A/E. In all cases, the Contractor will be deemed to have estimated the most stringent materials and methods (i.e. the highest quality materials and most expensive manner of completing the work) unless he has requested and obtained written authorization as to which methods or materials will be required.
 - 4. Each and every trade or subcontractor will be deemed to have familiarized himself with all drawings of this project, including Site/Civil, Architectural, Structural, Mechanical, Electrical, Information Technology, etc. so as to avoid coordination errors, omissions, and misinterpretations. No additional compensation will be authorized for alleged errors, omissions, and misinterpretation, whether they are a result of failure to observe these requirements or not.
- D. The complete set of Architectural, Structural, Civil, Mechanical, and Electrical drawings, specifications, and addenda apply to this work.

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1.2 SCOPE

- A. The work in Division-23 includes furnishing and installing the mechanical systems complete and ready for satisfactory service.
- B. Requirements specified govern work in all sections of Division-23.

1.3 REFERENCES

- A. References to standards, codes, catalogs and recommendations are latest edition in effect on date of invitation to bid.
- B. Refer to applicable contract drawings, specifications and addenda pertaining to other divisions for conditions affecting work.
- C. Refer to Division-01 for description of alternates.

1.4 DEFINITIONS

- A. Following are definitions of terms and expressions used in this Division:
 - 1. "Approve" - to permit use of material, equipment or methods conditional upon compliance with contract document requirements.
 - 2. "Concealed" - hidden from normal sight; includes work in crawl spaces, above ceilings, and in building shafts.
 - 3. "Directed" - directed by Engineer.
 - 4. "Ductwork" - includes ducts, fittings, housings, dampers, supports and accessories comprising a system.
 - 5. "Equal, equivalent" - possessing the same performance qualities and characteristics and fulfilling the same utilitarian function.
 - 6. "Exposed" - not concealed.
 - 7. "Indicated" - indicated in Contract Documents.
 - 8. "Piping" - includes pipe, fittings, valves, supports and accessories comprising a system.
 - 9. "Provide" - furnish and install.
 - 10. "Removable" - detachable from the structure or system without physical alteration of materials or equipment or disturbance to other construction.
 - 11. "Review" - limited observation or checking to ascertain general conformance with design concepts and general compliance with contract document requirements. Such action does not constitute a waiver or alteration of the contract requirements.

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Verification of quantities and dimensions shall be the responsibility of the Contractor.

12. "Appurtenances" - a device or assembly installed in the referenced system which performs some useful referenced function in the operation, maintenance, servicing, economy or safety of the system. Some examples include, but are not limited to aerators, anchors, supports, gauges, backflow preventers, expansion tanks, filters, flow controls, heat exchangers, interceptors, meters, pressure reducing valves, relief valves, dampers, separators and similar devices.
13. "Record Documents" - drawings, plans and specifications that indicate the nature and location of work reported by Contractors, but not verified by Consultant. Record documents cannot be considered reliable; as they are based on information reported by the Contractor only and is not verified by the Architect or Engineer (A/E).

1.5 RIGGING REQUIREMENTS

- A. Prior to bidding, the Contractor shall verify that all equipment can be physically rigged to the proposed location without disturbance or dismantling of any existing or new physical obstacles. Should the rigging of any new equipment appear to be an issue, the Contractor shall inform the Architect or Engineer (A/E) seven (7) days prior to the bid date that the rigging of the new equipment may present a problem. Otherwise, the Contractor shall, in accordance with the manufacturer's approval and without voiding warranties and/or certifications, have the equipment "broken down" into sections as required to install the equipment in its proposed location without disturbance or dismantling of any existing or new physical obstacles.
- B. Failure to inform the Architect or Engineer (A/E) seven (7) days prior to the bid of any rigging problems will result in the Contractor accepting full responsibility for all modifications to the equipment or the physical obstacles required to install the equipment in its proposed location without additional cost to the Owner.

1.6 CONTRACTOR'S INSTALLATION DRAWINGS

- A. Prior to fabrication and installation, submit shop drawings (min. scale - 1/4" = 1' - 0") illustrating all ductwork, HVAC piping, plumbing piping, lighting fixtures, cable tray, conduit, expansion loops, supports, alignment guides and fire protection coordinated with each other and with the structure. Installation drawings shall be reviewed by Owner's representative prior to fabrication and installation of any new work and prior to the ordering of any mechanical equipment.
- B. Should the Contractor not provide the coordinated installation drawings required above, the following shall apply:
 1. The Contractor shall accept full and absolute responsibility for the coordination of all project materials and equipment to be installed as indicated on the contract documents.

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2. Proposed change orders and/or time extensions will not be accepted for any additional work that results from coordination related changes.
 3. A credit shall be issued to the Owner for the value of the coordinated installation drawings; the value of the credit to the Owner shall be as determined by the A/E.
- C. Computer (CADD) files of mechanical drawings (HVAC, etc.) will not be made available to the Contractor for use in the preparation of coordinated drawings, shop drawings or any other use.

1.7 MATERIAL, EQUIPMENT AND SUBSTITUTION REQUIREMENTS

- A. Use products of one manufacturer where two or more items of same kind of equipment are required.
- B. Materials and equipment shall have a record of two (2) years successful field use.
- C. Where a specific manufacturer is listed on the drawings, that manufacturer shall be considered the basis of design for that particular item of equipment. Only the basis of design manufacturer has been verified to meet the project requirements (i.e. dimensions, weights, service clearances, electrical requirements, etc.).
- D. Where the drawings and/or specifications indicate more than one manufacturer for a particular item of equipment, only those listed may submit products and services to be included in the work; manufacturers other than those listed will not be acceptable. Should the contractor choose to use one of the specified manufacturers other than the basis of design, it shall be the responsibility of the contractor to verify that the equipment meets all project requirements including, but not limited to, verification of all dimensions, weights, service clearances, electrical requirements, etc. All changes incurred shall be the responsibility of the contractor and shall be provided at no additional cost to the owner.
- E. Substitutions must be submitted for consideration seven (7) days prior to the original bid date. Consideration of substitutions shall be at the sole discretion of the Engineer. Substitution submittals shall include all information required in the "Submittals" paragraph of this specification section, as well as all other requirements indicated through the Division-23 specifications. Substitutions will not mitigate, in any way, the Contractor's responsibility in complying with the coordination, contract requirements or design intent. Any additional electrical, structural or special requirements, etc. shall be the responsibility of the Contractor. Also, any additional cost incurred as a result of substitution shall be the responsibility of the Contractor.
- F. Nameplate: For each piece of power operated mechanical equipment provide a permanent operational data nameplate indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

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1.8 MATERIAL AND EQUIPMENT LIST

- A. Within thirty (30) days after award of the contract, submit for Engineer's review a list of subcontractors' and manufacturers' names for items proposed for this project.

1.9 SUBMITTALS

- A. Where the drawings and/or specifications indicate more than one allowable manufacturer for a particular piece of equipment and/or product, only those manufacturers indicated may submit products and services to be included in the work. Unless otherwise indicated, manufacturers other than those listed will not be acceptable.
- B. Submit shop drawings, manufacturer's data and certificates for equipment, materials and finish, and pertinent details for each system where specified in each individual section, and obtain approval before procurement, fabrication, or delivery of the items to the job site. Partial submittals are not acceptable and will be returned without review.
- C. Shop Drawings: Drawings shall include floor plans, sectional views, wiring diagrams, and installation details of equipment. Include equipment spaces identifying and indicating proposed location, layout and arrangement of items of equipment, control panels, accessories, piping, ductwork, and other items that must be shown to assure a coordinated installation. Wiring diagrams shall identify circuit terminals, and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. If equipment is disapproved, drawings shall be revised to show acceptable equipment and be resubmitted. All equipment and/or products shall be submitted by an authorized factory representative of that particular product.
- D. Manufacturer's Data: Submittals for each manufactured item shall be manufacturer's descriptive literature of cataloged products, equipment drawings, diagrams, performance and characteristic curves, and catalog cuts.
- E. Standards Compliance: When materials or equipment must conform to the standards of organizations such as the American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM), National Electrical Manufacturers Association (NEMA), American Society of Mechanical Engineers (ASME), American Gas Association (AGA), American Refrigeration Institute (ARI), and Underwriters' Laboratories (UL), proof of such conformance shall be submitted to the Engineer for review. If an organization uses a label or listing to indicate compliance with a particular standard, the label or listing will be acceptable evidence, unless otherwise specified in the individual sections. In lieu of the label or listing, the Contractor shall submit a certificate from an independent testing organization, which is competent to perform acceptable testing. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item conforms to the specified organization's standard. For materials and equipment whose compliance with organizational standards or specifications is not regulated by an organization using its own listing or label as proof of compliance, a certificate of compliance from the manufacturer shall be submitted for

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review. The certificate shall identify the manufacturer, the product, and the referenced standard and shall simply state that the manufacturer certifies that the product conforms to all requirements of the project specification and of the referenced standards listed.

- F. Contractor shall thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission and coordinate installation requirements for equipment submitted, including, a) the verification of equipment weights relative to the existing and/or new structural support system and b) the verification of equipment dimensions relative to existing and/or new architectural conditions. Contractor shall be responsible for correctness of all submittals.
- G. Submittals will be checked only for general conformance with the design concept and are subject to the original contract documents, as well as any corrections and comments noted. Comments noted, if any, will not be considered a complete list of all omissions, deviations and corrections necessary to meet the requirements of the contract documents. The contractor will be responsible to confirm that the final product and installation will be in conformance with the contract documents in their entirety, including the responsibility to fully coordinate all work with other trades and to confirm the correctness of dimensions, quantities, and capacities. Submittal review does not authorize or constitute a change to the contract requirements and does not release the contractor of responsibility to conform to the contract requirements. Requirements of the contract are not waived by review of any and all substitutions. The contractor must fulfill the terms of the contract.
- H. Compliance Review Form: Each equipment submittal must include a Compliance Review Form formatted as follows:
 - 1. Section 1: Certify that the submittal is in complete compliance with the plans and specifications, except for the numbered and footnoted deviations and exceptions as defined herein. Deviations or exceptions taken in a cover letter or by contradiction or omission shall not constitute a release from the requirement that the equipment be in complete compliance with the plans and specifications.
 - 2. Section 2: Provide a detailed paragraph by paragraph annotation of the specification with an individual "C", "D", or "E" noted in the margin, as follows:
 - a. "C" shall mean compliance with no exceptions. Provide a numbered footnote (i.e. C1, C2, C3, etc.) for each comment or clarification.
 - b. "D" shall mean compliance with deviations. For each deviation, provide a numbered footnote (i.e. D1, D2, D3, etc.) with a detailed explanation of how the intent of this specification is to be satisfied.
 - c. "E" shall mean exception. The equipment offered is not in compliance with the specifications. For each exception, provide a numbered footnote (i.e. E1, E2, E3, etc.) with a detailed description of the exception.
- I. Electronic Submittals: Should the contractor elect to submit electronic shop drawings/submittals, the procedure shall be as follows:
 - 1. Provide a transmittal with the electronic shop drawing/submittal indicating that the

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- document was transmitted electronically. Transmittal shall also include verification of the contractor's review indicating compliance with the contract documents in accordance with paragraph 1.09.F of this section.
2. Sequentially number all pages on the electronic shop drawing/submittal. The total number of pages shall be reflected in the transmittal.
 3. Submittal review comments shall be transmitted electronically. Large documents will be scanned with comments as necessary and returned electronically.
 4. All shop drawings such as, but not limited to: coordination drawings, ductwork shop drawings, fire alarm drawings, ductbank layouts, etc. shall be submitted in hard copy, full size format.
 5. Provide hard copy of the shop drawing/submittal for each of the Operations and Maintenance Manuals.
 6. Failure to comply with the above will result in the submittal being returned and marked "Not Reviewed".
- J. Submittals will be reviewed for general compliance with design concept in accordance with contract documents. Dimensions, quantities, weights, or other details will not be verified by the A/E; this is the responsibility of the Contractor.
- K. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted.
- L. Review Period: BKM shall be allotted two (2) weeks for the processing, review and return of all submittals. It shall be incumbent upon the Contractor to include this time period in their schedule.
 1. Resubmittals: BKM shall be allotted an additional two weeks (14 days) for the review of each resubmittal. Again, it shall be the Contractor's responsibility to submit the appropriate materials in a timely fashion.
 2. Contract Extension: No extension in contract time will be authorized as a result of the timeline addressed above.
- M. Submittal Identifications:
 1. Place a permanent label or title block on each submittal for identification.
 2. Indicate name of firm or entity that prepared each submittal on label or title block.
 3. Provide a space approximately 4 by 5 inches on label or beside title block to record contractor's review and approval markings and action taken by A/E.
 4. Include the following information on label for processing and recording action taken:
 - a. Project name

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- b. Date
 - c. Name and address of A/E
 - d. Name and address of contractor
 - e. Name and address of subcontractor
 - f. Name and address of supplier
 - g. Name of manufacturer
 - h. Unique identifier, including revision number
 - i. Number and title of appropriate specification section
 - j. Drawing number and detail references, as appropriate
 - k. Other necessary identification
 - l. Example: 230700-01-0
 - 1) 230700 references the spec section
 - 2) 01 indicates this is the first submittal from this spec section
 - 3) 0 indicates this is the original submittal (where 1 would indicate this is the first re-submittal)
- N. The engineer will provide a maximum of two (2) submittal reviews per equipment submittal; the initial review plus one (1) re-submittal. Should the re-submittal be returned "Not Acceptable" or "Revise and Resubmit", the contractor shall choose one of the following courses of action:
- 1. Provide the exact manufacturer and model indicated in the contract documents as the basis of design, or
 - 2. Reimburse the engineer for all additional review time required to achieve a submittal review from the engineer of "No Exceptions Taken."
 - 3. Should the contractor choose option 2 above, the engineer shall be reimbursed at an hourly rate of \$175 per hour with payment due prior to the return of the final submittal. In addition, the contractor shall accept complete responsibility for all delays resulting from the submittal review process extending beyond two (2) reviews per equipment submittal.
- O. Resubmittals: Resubmittals shall comply with paragraph 1.09 of this section and the following additional requirements.
- 1. Resubmittals shall include a written response to each submittal comment. Provide a detailed comment by comment annotation of the submittal review comments with an individual "C", "D", or "E" as follows:

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- a. "C" shall mean compliance with no exceptions. Provide a numbered footnote (i.e. C1, C2, C3, etc.) for each comment or clarification.
- b. "D" shall mean compliance with deviations. For each deviation, provide a numbered footnote (i.e. D1, D2, D3, etc.) with a detailed explanation of how the intent of this specification is to be satisfied.
- c. "E" shall mean exception. The equipment offered is not in compliance with the specifications. For each exception, provide a numbered footnote (i.e. E1, E2, E3, etc.) with a detailed description of the exception.

1.10 MANUFACTURER'S RECOMMENDATIONS

- A. Installation procedures are required to be in accordance with the recommendations of the manufacturer of the material being installed.

1.11 ACCESSIBILITY

- A. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing.

1.12 SAFETY REQUIREMENTS

- A. Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts located so that any person can come in close proximity thereto shall be fully enclosed or properly guarded in accordance with OSHA. High-temperature equipment and piping so located as to endanger personnel or create a fire hazard shall be properly guarded or covered with insulation of a type as specified herein. Items such as catwalks, ladders, and guardrails shall be provided where required for safe operation and maintenance of equipment.

1.13 WORKMANSHIP

- A. Remove and replace, at no extra cost, all work not orderly, reasonably neat, or workmanlike.
- B. Coordinate all work and cooperate with other trades to facilitate execution of work.

1.14 SITE EXAMINATION/EXISTING CONDITIONS VERIFICATION

- A. Failure to visit site and become familiar with existing conditions prior to bidding will not relieve the Contractor of responsibility for complying with the Contract documents.
- B. Contractor shall field verify existing services and direction of flow of piping and ductwork prior to connection. Existing mechanical identification shall not constitute proper

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verification of service or direction of flow.

1.15 REGULATIONS AND PERMITS

- A. Comply with all applicable codes and regulations.
- B. All equipment provided shall be in accordance with all applicable local, state, and federal codes, guidelines and standards, as well as the authority having jurisdiction. Equipment and installation shall be in compliance with all applicable energy codes including the most current version of ASHRAE Standard 90.1.
- C. Obtain and pay for all required permits.

1.16 CUTTING AND PATCHING

- A. Unless otherwise directed, do all cutting and patching. Damaged work, including fireproofing and waterproofing shall be repaired by skilled mechanics of the trade involved.
- B. Do not cut walls, floors, roofs, reinforced concrete or structural steel without structural Engineer's permission. Install services without affecting reinforcing steel.
- C. In precast concrete plank drill all holes with a Carboloy tipped drill. Follow instructions of structural Engineer. Cut no reinforcing bars.

1.17 LINTELS

- A. Under this Section provide all lintels not provided elsewhere which are required for openings for the installations of mechanical work. Lintels shall meet the requirements of the structural sections.

1.18 CLEANING UP

- A. Keep premises free from accumulation of debris.
- B. Remove tools, scaffolding, surplus material, debris, and leave premises broom clean.
- C. On discontinuance of part of the work, place all debris in containers and promptly remove them from the Owner's property.
- D. Leave all areas broom clean.
- E. Final clean-up shall be performed.

1.19 PROTECTION

- A. Protect mechanical and electrical material and equipment from the elements or other

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- injury as soon as delivered on premises.
- B. Cap or plug openings in equipment, piping, duct, and conduit systems to exclude dirt and other foreign material. Rags, wool, cotton, paper, waste or similar materials shall not be used for plugging.
 - C. Unless approved by Owner, HVAC equipment shall not be used for temporary heating or ventilation during construction.
 - D. Contractor shall protect all existing mechanical, electrical and architectural equipment, materials, finishes, etc. located within or adjacent to the work environment. Contractor shall be responsible for restoration of all existing mechanical, electrical and architectural items to remain. All equipment to remain must be restored to its pre-existing condition prior to the start of work. Restoration and/or replacement shall be at no cost to the Owner.
 - E. Contractor shall provide temporary cooling and heating as required to protect all construction materials from the potential adverse effects of high or low temperature and humidity. Upon delivery of ceiling and other finish materials to a location within the building, environmental conditions in all spaces where the materials will be either stored or installed shall be permanently maintained at 75°F (+2°F) and 50% RH (+5%). Should the HVAC include a reheat system, the reheat system shall be energized to provide temperature and humidity control whenever the HVAC system is energized. Contractor shall pay for all utility, fuel, operational, maintenance and repair costs associated with providing the environmental conditions indicated above until the owner accepts occupancy of the building.

1.20 CLEANING OF SYSTEMS

- A. After satisfactory completion of pressure tests and before permanently connecting fixtures, equipment, traps, strainers and other accessory items, thoroughly clean all systems. Blow out and flush piping until interiors are free of foreign matter.
- B. Flush piping in recirculating water systems to remove all cutting oil, excess pipe joint compound and other foreign materials. Furnish necessary temporary pumping equipment to thoroughly clean the water piping. Do not use any system pump until after cleaning and flushing has been accomplished to the satisfaction of the Engineer. Employ chemical cleaners, including a non-foaming detergent, not harmful to system components. After cleaning operation, final flushing and refilling the residual alkalinity shall not exceed 300 parts per million. Work shall be performed or supervised by a qualified water treatment service company with personnel skilled in the safe and proper use of chemicals and in testing procedures. After completion, submit a certificate of completion to Engineer stating name of the service company used.
- C. Leave strainers and dirt pockets in clean condition.
- D. Clean fans, ductwork, enclosures, flues, registers, grilles and diffusers at completion of work.
- E. Permanent air systems operated for temporary heating during construction shall only be operated with filters installed of equal efficiency to those specified. Prior to acceptance

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and after cleaning of system, replace with clean filters as specified. Return air openings shall be equipped with filter cloth to protect against debris entering the ductwork.

1. If upon periodic inspection, it is determined that the permanent ductwork has become contaminated with construction debris, then the contractor shall be required to procure the services of a professional duct cleaning agency prior to substantial completion, at no additional cost to the Owner.
- F. Should any system become clogged with construction refuse after acceptance, the contractor shall pay for all labor and materials required to locate and remove the obstruction and replace and repair work disturbed.
- G. Leave all systems clean, and in complete running order.
- H. Equipment that has been subjected to the elements shall be cleaned of all rust, dirt and debris and repainted to match original finish.

1.21 FUNCTIONAL PERFORMANCE TESTING AND VERIFICATION

- A. General: In addition to the tests required during and after installation of all mechanical systems, as well as any other formal commissioning requirements, the Contractor shall perform functional performance tests to verify that all systems are designed, installed, calibrated and adjusted to perform as required in the Contract.
- B. Comply with all applicable specification sections including, but not be limited to, "Basic HVAC Requirements", "Testing, Adjusting and Balancing", "Automatic Temperature Controls" and "Commissioning", where applicable.
- C. Prior to functional performance testing, all indicating, recording and control devices shall be calibrated. A verification calibration report shall be provided with the final test report.
- D. Provide functional performance testing to verify proper operation of each and every control sequence indicated throughout the contract documents.
- E. Failure of Tests: Should any test, verification, or demonstration fail to meet the specification requirements, the component of the system causing the failure shall be repaired, replaced or readjusted. The failed test, verification, or demonstration shall then be repeated.
- F. A "Functional Performance Test Verification Form" is included at the end of Section 230900. This form (electronic version is available upon request) shall be completed for all mechanical equipment provided under this contract. This shall include, but not be limited to each air handling unit, fan, pump, VAV terminal, DX cooling equipment, miscellaneous heating equipment, etc.
- G. Test Report: Upon satisfactory verification of calibration and functional performance tests, a copy of the final test results shall be bound in the operations and maintenance manual. The final report shall also include a full compliance statement, on company letterhead, indicating that all systems are installed and functioning per the contract requirements including drawings, specifications, control sequences and accepted

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submittals.

- H. The mechanical systems shall not be considered complete until all functional performance verification forms, calibration reports and compliance statement have been submitted and reviewed. Submit in accordance with the submittal requirements indicated elsewhere in these specifications.

1.22 OPERATING AND MAINTENANCE MANUAL

- A. Submit Operation and Maintenance Manuals as follows:

1. Provide an electronic version for review by the Owner and A/E, including bookmarks of all section and subsections.
2. After acceptance of the electronic copy, produce hard copies in three-ring binders with each section separated by tab divider. Include protective plastic sleeves for any software or folded large documents submitted. Provide a minimum of two (2) copies to the Owner.

- B. At a minimum, the manual shall contain the following:

1. Title page
2. Table of contents
3. Contractor and sub-contractor contact information
4. Supplier contact information for all mechanical equipment
5. Copies of manufacturer's and contractor's warranty information (project and equipment) for all mechanical equipment.
6. Submittal log for all mechanical equipment
7. One (1) reviewed copy of each shop drawing or submittal incorporating all A/E and owner submittal review comments.
8. Copy of inspector acceptance certificates / documents.
9. Provide an 11 x 17 fold-out drawing of each floor plan and indicate locations of the following:
 - a. System shutoff valves
 - b. Fire/smoke dampers
10. All duct, pipe and equipment pressure test reports complete with 11 x 17 fold-out drawing, indicating all systems tested.
11. Final Test and Balance (TAB) Reports. Do not include reports that have not been accepted by the A/E. Pencil or partial copies will not be acceptable.

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12. Maintenance procedures for each item of mechanical equipment to include frequency and type of maintenance, spare parts and attic/stock list. This shall include the manufacturer's literature indicating operating and maintenance instructions, parts list, illustrations and diagrams.
13. An itemized list of all spare parts and specialty tools shall be transmitted to the Owner.
14. A report of the training procedures and content provided as well as the attendance log.
15. Valve tag chart
16. Mechanical systems functional performance verification forms, calibration reports and compliance statement indicating that all systems are installed and functioning per the contract requirements.

1.23 TOOLS AND LUBRICANTS

- A. Furnish and turn over to the Owner, special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.
- B. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.
- C. Tool Containers: Hardwood or metal, permanently identified for intended service and mounted, or located, where directed by the Owner.
- D. Lubricants: A minimum of one quart (.9 L) of oil, and one pound (450 g) of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

1.24 FIELD INSTRUCTION

- A. Upon completion of work, instruct Owner's representative in the proper operation and maintenance of the mechanical and electrical systems.
- B. Instruction periods specified below shall be in addition to instruction specified for certain items elsewhere in the specifications.
- C. Instructions shall be given by persons expert in the following systems and equipment and shall include descriptions and demonstration of procedures, data logging, and analysis.
- D. Instructions shall be given by persons expert in the operation and maintenance and shall be for a period of not less than . two (2) eight hour days.
- E. Prepare statement(s) for signing by Owner's representative indicating date of completion of instructions and hours expended. Furnish copy of signed statement to Engineer.

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- F. Final mechanical demonstration of all mechanical equipment shall be recorded in DVD compatible format. Provide DVD's to the Owner.

1.25 RECORD DOCUMENTS

- A. The Contractor shall maintain a record set of mechanical prints at the project site and shall indicate thereon any changes made to the contract drawings, including, but not limited to addenda, field sketches, RFI responses, supplemental drawings, sketches, etc. Where changes are made that are reflective of supplemental instructions, revisions, RFI responses, etc., the Contractor shall make clear references to those changes.
- B. A separate set of neat, legible mechanical contract prints shall be kept at the project site at all times during the construction of the work for the express purpose of showing any and all changes indicated in paragraph A. above. The prints shall be marked up daily showing all changes to the original documents. The prints shall be marked up in a neat, legible manner using a red pen. Periodic review of the Record Documents will be conducted by the Owner's Representative or A/E. Should this review indicate that the Record Documents are deficient or not up to date, the Contractor shall immediately bring the documents into compliance and make the corrections.
- C. Upon completion of the project and before final close-out, the Contractor shall be responsible for producing a final set of record documents in electronic CADD format. One (1) set of full size prints, one (1) CD of the electronic CADD drawings (in AutoCad and pdf format), along with the red-lined marked up field set shall be delivered to the owner upon completion. If requested, the electronic CADD documents shall be uploaded to the owner's FTP site. The final CADD documents shall indicate in the title or revision block "RECORD DOCUMENTS" along with the date completed. The electronic format shall be compatible with the owner's preferred version of AutoCad. Coordinate with the owner before producing the CD or up-loading to the FTP site. Not acceptable are contractor installation drawings, shop drawings or multi-layers of work on a single drawing. The final as-built product shall mirror the contract bid documents using the project page layout, format and project title block.
- D. Computer (CADD) files of mechanical drawings will be made available to the Contractor upon receipt of a signed waiver (available upon request). One CD will be made available to the general contractor or construction manager for distribution to the trades.
- E. Should the Contractor's electronic Record Documents not be considered complete, they will be returned for completion and/or correction.

1.26 DEMOLITION

- A. All demolition of existing mechanical and electrical piping, auxiliaries and equipment, shall be as specified under the Architectural "Demolition" section, of these specifications, as shown on the drawings, and as required to complete the new and renovated installations and shall be performed by the respective mechanical and electrical contractors.
- B. This work shall include the disconnection and capping of existing services, relocation of

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certain equipment, and the removal of existing piping, wiring, fittings, equipment, including heat transfer units, air handling units, fans, electrical controls and panelboxes, ductwork, etc., not reused in the new work or required to complete the renovation work. Contractor shall note the drawings specify certain existing equipment to be reused.

- C. Where supports and piping are removed, holes remaining in floors, walls and ceilings must be patched and refinished to match the adjoining original surfaces and finishes.
- D. Any removed items requested by the Owner shall remain the property of the Owner. Contractor shall remove equipment and store on site as directed by the Owner. All other equipment or material shall become the property of the Contractor and shall be removed from the site. Contractor shall meet Federal EPA Laws, Regulations and Guidelines in regard to removal of asbestos insulation.
- E. The contractor shall use care when performing selective building and site demolition. The contractor shall be responsible for damage inclusive of but not limited to: building finishes, lighting (interior and exterior), furniture, structure, site, utilities (above and below ground), mechanical, plumbing, telecommunications and electrical equipment / systems. Should any damage occur or should any remedial work be required, the contractor shall be responsible to repair and or replace the damaged item(s) to the Owner's satisfaction at no additional cost. The contractor shall be responsible for surveying (including contacting Miss Utility), photo documenting and restoring the surrounding work site(s) to the original pre-demolition condition and / or to the Owner's satisfaction upon completion of the work at no additional cost.

1.27 OUTAGES

- A. All mechanical outages which will interfere with the normal use of the building in any manner shall be done at such times as shall be mutually agreed upon by the Contractor and the Owner's Representative.
- B. Unless otherwise specified, outages of any services required for the performance of this contract and affecting areas other than the immediate work area shall be scheduled at least ten (10) days in advance with the Owner's Representative. All such outages shall be performed during other than normal duty hours.
- C. The Contractor shall include in his price the cost of all premium time required for outages and other work which interferes with the normal use of the building, which will be performed, in most cases, during other than normal work time and the convenience of the using agency.

1.28 GUARANTEE/WARRANTY

- A. Each Contractor shall furnish a guarantee covering all labor and materials furnished by him for a period of two (2) years from the date of final acceptance of his work, and he shall agree to repair and make good at his own expense any and all defects which may appear in his work during that time if, in the judgment of the Engineer, such defects arise from defective workmanship and/or imperfect or inferior material.

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- B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or warranty. Certificates of guarantee shall be delivered to the Owner.
- C. Within the two (2) year warranty/guarantee period, manufacturer's recommended maintenance shall be provided by the Contractor.
- D. In addition to the warranties indicated above, provide a five (5) year parts and labor warranty for each of the following:
 1. All air conditioning unit related compressors (i.e. rooftop DX units, all air cooled condensing units for split system units, etc.).

1.29 UTILITY REBATE

- A. Utility Rebate Application: The mechanical contractor shall provide and submit a utility rebate application to the local utility (BGE Smart Energy Program, or other local utility serving this project area) for the major HVAC equipment (such as packaged rooftop A/C units, etc.). The rebate application shall include all information required by the utility company program administrator (ICF International, or other rebate administrator) including, but not limited to, the application, supporting calculations, analysis, comparison of the proposed equipment to baseline equipment or system., etc.; all as defined and/or required by the program administrator. The Owner shall be indicated on the application as the recipient for the full rebate.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

Not Applicable

END OF SECTION 230100

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SECTION 230200 - PROJECT CLOSEOUT HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. This section provides a summary of the primary mechanical project closeout activities, however, this section does not attempt to address all project closeout requirements. Closeout activities referenced in this section include the following:
 - 1. Pressure Testing
 - 2. Start-up
 - 3. Punch-out Procedures
 - 4. Testing, Adjusting and Balancing
 - 5. Functional Performance Testing and Verification
 - 6. Operation and Maintenance Manuals (O & M Manuals)
 - 7. Demonstration and Training
 - 8. Record Documents
 - 9. Close-out Documents
- B. This Section shall not supersede any other close-out section or requirements of the Contract. Refer to other Divisions of the specifications and the General Requirements of the Contract for further instructions.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

3.1 PRESSURE TESTING

- A. Piping: The Contractor shall perform pressure testing on all piping systems as indicated in Division-23 section "Testing, Adjusting and Balancing", and elsewhere as indicated.
- B. Ductwork: The Contractor shall perform pressure testing on all ductwork systems as indicated in Division-23 sections, "Testing, Adjusting and Balancing", "Low Pressure

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- Ductwork" and "High Pressure Ductwork" and elsewhere as indicated.
- C. Air Handling Units: The Contractor shall perform factory and / or field pressure testing on all air handling units where required by the drawings or specifications.
 - D. Final pressure test results shall be submitted as a separate project submittal for review and included with the Test and Balance Report. Upon review for general conformance, include all pressure tests in the O & M Manual.
 - E. All factory performed equipment test results shall be included in the final O & M Manuals.
 - F. Where re-tests were required, indicate remedial action taken and submit in test report.

3.2 START-UP

- A. The Contractor shall perform start-up on each piece of mechanical equipment as specified in each section of Division-23.
- B. Where indicated in each section of Division-23, the services of a factory authorized and certified technician shall be required to perform the equipment start-up. Start-up by any other organization other than as required by the manufacturer is unacceptable.
- C. Start-up reports shall be provided for all equipment and be included in the final O & M Manuals.

3.3 PUNCH-OUT PROCEDURES

- A. Preliminary Punch-out:
 1. Prior to requesting an inspection from the Owner, Engineer, or Permit Official, the General Contractor or Construction Manager (GC or CM) shall provide a preliminary punch-out of the area in question.
 2. Once completed, their punch list shall be supplied to each trade for corrections and completion. The punch list shall also be provided to the Engineer for their use.
 3. Upon being informed that the trade contractors have addressed all of the outstanding items, the GC / CM shall backcheck the work and update the punch list.
- B. Final Punch-out:
 1. Final punch-out by the engineer shall not commence until the GC or CM has exhausted their review and has signed off on all items.
 2. A copy of the sign-off shall be provided to the Engineer for their record.
 3. Once the above has been completed, the Engineer shall be notified that the work is substantially complete and ready for a final punch-out.

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4. Depending on the size, schedule, and project complexity, punch-outs may be requested for specific areas or systems, rather than the facility as a whole. Examples of specific requests include the following:
 - a. Above ceiling
 - b. Equipment rooms
- C. Upon completion of any and all punch lists (i.e. above ceiling, final, partial, phased, factory review, or specific item) the contractor shall provide an item by item sign-off indicating the date and who completed the item. The sign-off shall be submitted to the A/E and owner before final payment is processed. Should the contractor disagree with any item, they shall provide a written exception giving reason for review.

3.4 TESTING, ADJUSTING AND BALANCING

- A. Comply with all provisions of Division-23 Section, "Testing, Adjusting and Balancing" (TAB) for the systems listed, but not limited to, the following:
 1. Building Automated Systems
 2. Fans
 3. Air Handling Units
 4. Ductwork Systems
 5. Pumps
 6. Piping Systems
 7. Terminal Units
- B. TAB reports shall be submitted as a separate project submittal for review. Upon review for general conformance, include the final TAB report in the O & M Manual.
- C. Comply with testing, adjusting and balancing requirements as indicated in each section within Division-23.

3.5 FUNCTIONAL PERFORMANCE TESTING AND VERIFICATION

- A. General: In addition to the tests required during and after installation of all mechanical systems, as well as any other formal commissioning requirements, the Contractor shall perform functional performance tests to verify that all systems are designed, installed, calibrated and adjusted to perform as required in the Contract.
- B. Comply with all applicable specification sections including, but not be limited to, "Basic HVAC Requirements", "Testing, Adjusting and Balancing", "Automatic Temperature Controls" and "Commissioning", where applicable.

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- C. Prior to functional performance testing, all indicating, recording and control devices shall be calibrated. A calibration verification report shall be provided with the final test report.
- D. Provide functional performance testing to verify proper operation of each and every control sequence indicated throughout the contract documents.
- E. Failure of Tests: Should any test, verification, or demonstration fail to meet the specification requirements, the component of the system causing the failure shall be repaired, replaced or readjusted. The failed test, verification, or demonstration shall then be repeated.
- F. A "Functional Performance Test Verification Form" is included at the end of Section 230900. This form (electronic version is available upon request) shall be completed for all mechanical equipment provided under this contract. This shall include, but not be limited to each air handling unit, fan, pump, VAV terminal, , DX cooling equipment, miscellaneous heating equipment, etc.
- G. Test Report: Upon satisfactory verification of calibration and functional performance tests, a copy of the final test results shall be bound in the operations and maintenance manual. The final report shall also include a full compliance statement, on company letterhead, indicating that all systems are installed and functioning per the contract requirements including drawings, specifications, control sequences and accepted submittals.
- H. The mechanical systems shall not be considered complete until all functional performance verification forms, calibration reports and compliance statement have been submitted and reviewed. Submit in accordance with the submittal requirements indicated elsewhere in these specifications.

3.6 OPERATION AND MAINTENANCE MANUALS

- A. Submit Operation and Maintenance Manuals as follows:
 1. Provide an electronic version for review by the Owner and A/E, including bookmarks of all section and subsections.
 2. After acceptance of the electronic copy, produce hard copies in three-ring binders with each section separated by tab divider. Include protective plastic sleeves for any software or folded large documents submitted. Provide a minimum of two (2) copies to the Owner.
- B. At a minimum, the manual shall contain the following:
 1. Title page
 2. Table of contents
 3. Contractor and sub-contractor contact information
 4. Supplier contact information for all mechanical equipment

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5. Copies of manufacturer's and contractor's warranty information (project and equipment) for all mechanical equipment.
6. Submittal log for all mechanical equipment
7. One (1) reviewed copy of each shop drawing or submittal incorporating all A/E and owner submittal review comments.
8. Copy of inspector acceptance certificates / documents.
9. Provide an 11 x 17 fold-out drawing of each floor plan and indicate locations of the following:
 - a. System shutoff valves
 - b. Fire/smoke dampers
10. All duct, pipe and equipment pressure test reports complete with 11 x 17 fold-out drawing, indicating all systems tested.
11. Final Test and Balance (TAB) Reports. Do not include reports that have not been accepted by the A/E. Pencil or partial copies will not be acceptable.
12. Maintenance procedures for each item of mechanical equipment to include frequency and type of maintenance, spare parts and attic/stock list. This shall include the manufacturer's literature indicating operating and maintenance instructions, parts list, illustrations and diagrams.
13. An itemized list of all spare parts and specialty tools shall be transmitted to the Owner.
14. A report of the training procedures and content provided as well as the attendance log.
15. Valve tag chart
16. Mechanical systems functional performance verification forms, calibration reports and compliance statement indicating that all systems are installed and functioning per the contract requirements.

3.7 DEMONSTRATION AND TRAINING

- A. Upon completion of work, instruct the owner's representative in the proper operation and maintenance of each mechanical system in accordance with applicable specification sections.
- B. Instructions shall be given by persons expert in the operation and maintenance of each system / equipment.
- C. Prepare statement(s) for signing by Owner's representative indicating the date of

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completion of instructions and hours expended. Furnish copies of signed statements to the A/E.

- D. Final demonstration of all mechanical equipment shall be recorded in DVD compatible format.
 - 1. The recordings shall be organized systemically from largest to smallest component.
 - 2. The recordings shall include bookmarks to reference each type of equipment, all major components, and each component requiring regular maintenance.
 - 3. No segment shall be unannotated longer than fifteen minutes.
 - 4. Submit a digital link of the draft for review by the owner and A/E.
 - 5. Submit two hardcopy DVDs of the final approved copy to the owner's representative.
 - 6. Submit a digital link of the final approved copy to the owner's representative.

3.8 RECORD DOCUMENTS

- A. The Contractor shall maintain a record set of mechanical prints at the project site and shall indicate thereon any changes made to the contract drawings, including, but not limited to addenda, field sketches, RFI responses, supplemental drawings, sketches, etc. Where changes are made that are reflective of supplemental instructions, revisions, RFI responses, etc., the Contractor shall make clear references to those changes.
- B. A separate set of neat, legible mechanical contract prints shall be kept at the project site at all times during the construction of the work for the express purpose of showing any and all changes indicated in paragraph A. above. The prints shall be marked up daily showing all changes to the original documents. The prints shall be marked up in a neat, legible manner using a red pen. Periodic review of the Record Documents will be conducted by the Owner's Representative or A/E. Should this review indicate that the Record Documents are deficient or not up to date, the Contractor shall immediately bring the documents into compliance and make the corrections
- C. Upon completion of the project and before final close-out, the Contractor shall be responsible for producing a final set of record documents in electronic CADD format. One (1) set of full size prints, one (1) CD of the electronic CADD drawings (in AutoCad and pdf format), along with the red-lined marked up field set shall be delivered to the owner upon completion. If requested, the electronic CADD documents shall be uploaded to the owner's FTP site. The final CADD documents shall indicate in the title or revision block "RECORD DOCUMENTS" along with the date completed. The electronic format shall be compatible with the owner's preferred version of AutoCad. Coordinate with the owner before producing the CD or up-loading to the FTP site. Not acceptable are contractor installation drawings, shop drawings or multi-layers of work on a single drawing. The final as-built product shall mirror the contract bid documents using the project page layout, format and project title block.

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- D. Computer (CADD) files of mechanical drawings will be made available to the Contractor upon receipt of a signed waiver (available upon request). One CD will be made available to the general contractor or construction manager for distribution to the trades.
- E. Should the Contractor's electronic Record Documents not be considered complete, they will be returned for completion and/or correction.

3.9 CLOSEOUT DOCUMENTS

- A. Prior to Substantial Completion and /or Final Payment, the Contractor shall prepare and submit the following:
 - 1. Final punch lists indicating completion of all items
 - 2. All record drawings
 - 3. All record specifications
 - 4. Operation and Maintenance Manuals
 - 5. Complete final cleaning
 - 6. Remove temporary facilities and complete site restoration

END OF SECTION 230200

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SECTION 230500 - BASIC HVAC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-01 Specification Sections, apply to this Section.
- B. Requirements specified in Division-23 Section "Basic HVAC Requirements" apply to this Section.

1.2 SUMMARY

- A. This Section includes limited scope general construction materials and methods for application with mechanical installations as follows:
 - 1. Mechanical equipment nameplate data.
 - 2. Selective demolition including:
 - a. Nondestructive removal of materials and equipment for reuse or salvage as indicated.
 - b. Dismantling mechanical materials and equipment made obsolete by these installations.
 - 3. Miscellaneous metals for support of mechanical materials and equipment.
 - 4. Wood grounds, nailers, blocking, fasteners, and anchorage for support of mechanical materials and equipment.
 - 5. Access panels and doors in walls, ceilings, and floors for access to mechanical materials and equipment.

1.3 DEFINITIONS

1.4 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division-01 Specification Sections.
- B. Product data for the following products:
 - 1. Access panels and doors

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- C. Firestopping: Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures.
 - 1. Provide details of each proposed assembly identifying intended products and applicable UL system number, or UL classified devices.
 - 2. Provide drawings relating to non-standard applications as needed.
- D. Shop drawings detailing fabrication and installation for metal fabrications, and wood supports and anchorage for mechanical materials and equipment.
- E. Coordination drawings for access panel and door locations in accordance with Division-23 sections.
- F. Welder certificates, signed by Contractor, certifying that welders comply with requirements specified under "Quality Assurance" article of this Section.
- G. Schedules indicating proposed methods and sequence of operations for selective demolition prior to commencement of Work. Include coordination for shut-off of utility services and details for dust and noise control.
 - 1. Coordinate sequencing with construction phasing and Owner occupancy specified in Division-01 Section "Summary of Work."

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an Installer for the installation and application of joint sealers, access panels and doors, and firestopping materials with at least two years' experience with installations.
- B. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."
 - 1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.
- C. Fire-Resistance Ratings: Where a fire-resistance classification is indicated, provide access door assembly with panel door, frame, hinge, and latch from manufacturer listed in the UL "Building Materials Directory" for rating shown.
 - 1. Provide UL Label on each fire-rated access door.
- D. Local and State Regulatory Requirements: Submit forms or acceptance for proposed assemblies not conforming to specific UL firestop system numbers, or UL classified devices.

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1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver joint sealer materials in original unopened containers or bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.
- B. Store and handle joint sealer materials in compliance with the manufacturers' recommendations to prevent their deterioration and damage.

1.7 PROJECT CONDITIONS

- A. Conditions Affecting Selective Demolition: The following project conditions apply:
 - 1. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
 - 2. Locate, identify, and protect mechanical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.

1.8 SEQUENCE AND SCHEDULING

- A. Coordinate the shut-off and disconnection of utility services with the Owner and the utility company.
- B. Notify the Architect at least five (5) days prior to commencing demolition operations.
- C. Perform demolition in phases as indicated.

PART 2 - PRODUCTS

2.1 MECHANICAL EQUIPMENT NAMEPLATE DATA

- A. Nameplate: For each piece of power operated mechanical equipment provide a permanent operational data nameplate indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

2.2 MISCELLANEOUS METALS

- A. Steel plates, shapes, bars, and bar grating: ASTM A 36.
- B. Cold-Formed Steel Tubing: ASTM A 500.
- C. Hot-Rolled Steel Tubing: ASTM A 501.

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- D. Steel Pipe: ASTM A 53, Schedule 40, welded.
- E. Non-shrink, Non-metallic Grout: Premixed, factory-packaged, non-staining, non-corrosive, non-gaseous grout, recommended for interior and exterior applications.
- F. Fasteners: Zinc-coated, type, grade, and class as required.

2.3 MISCELLANEOUS LUMBER

- A. Framing Materials: Standard Grade, light-framing-size lumber of any species. Number 3 Common or Standard Grade boards complying with WCLIB or AWPA rules, or Number 3 boards complying with SPIB rules. Lumber shall be preservative treated in accordance with AWPB LP-2, and kiln dried to a moisture content of not more than 19 percent.
- B. Construction Panels: Plywood panels; APA C-D PLUGGED INT, with exterior glue; thickness as indicated, or if not indicated, not less than 15/32 inches (12 mm).

2.4 ACCESS DOORS

- A. Steel Access Doors and Frames: Factory-fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded steel, with welds ground smooth and flush with adjacent surfaces.
- B. Frames: 16-gage (1.6 mm) steel, with a 1-inch (25 mm) wide exposed perimeter flange for units installed in unit masonry, pre-cast, or cast-in-place concrete, ceramic tile, or wood paneling.
 - 1. For Installation in Masonry, Concrete, Ceramic Tile, or Wood Paneling: 1-inch (25 mm) wide exposed perimeter flange and adjustable metal masonry anchors.
 - 2. For Gypsum Wallboard or Plaster: Perforated flanges with wallboard bead.
 - 3. For Full-Bed Plaster Applications: Galvanized expanded metal lath and exposed casing bead, welded to perimeter of frame.
- C. Flush Panel Doors: 14-gage (2 mm) sheet steel, with concealed spring hinges or concealed continuous piano hinge set to open 175 degrees (3.05 Radians); factory-applied prime paint.
 - 1. Fire-Rated Units: Insulated flush panel doors, with continuous piano hinge and self-closing mechanism.
- D. Locking Devices: Flush, screwdriver-operated cam locks.

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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 installation and application of joint sealers and access panels. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 SELECTIVE DEMOLITION

- A. General: Demolish, remove, demount, and disconnect abandoned mechanical materials and equipment indicated to be removed and not indicated to be salvaged or saved.
- B. Materials and Equipment to be Salvaged: Remove, demount, and disconnect existing mechanical materials and equipment indicated to be removed and salvaged, and deliver materials and equipment to the location designated for storage.
- C. Disposal and Cleanup: Remove from the site and legally dispose of demolished materials and equipment not indicated to be salvaged.
- D. Mechanical Materials and Equipment: Demolish, remove, demount, and disconnect the following items:
 1. Inactive and obsolete piping, fittings and specialties, equipment, ductwork, controls, fixtures, and insulation.
 2. Piping and ducts embedded in floors, walls, and ceilings may remain if such materials do not interfere with new installations. Remove materials above accessible ceilings. Drain and cap piping and ducts that are allowed to remain.
 3. Perform cutting and patching required for demolition in accordance with Division-1 Section "Cutting and Patching."

3.3 ERECTION OF METAL SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.
- B. Field Welding: Comply with AWS "Structural Welding Code."

3.4 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

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- B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.5 INSTALLATION OF ACCESS DOORS

- A. Provide access doors (minimum 18" x 18") as required to provide maintainable access to all mechanical equipment including, but not limited to, valves, dampers, air terminals, etc.
- B. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
- C. Adjust hardware and panels after installation for proper operation.

END OF SECTION 230500

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SECTION 230513 - ELECTRICAL PROVISIONS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of electrical provisions to be provided as mechanical work is indicated in all other Division-23 sections, on drawings, and as further specified in this section.
- B. Types of work normally recognized as electrical, but provided as mechanical, specified or partially specified in this section, include but are not necessarily limited to the following:
 - 1. Motors for mechanical equipment.
 - 2. Motor starters and Variable Frequency Drives (VFDs) for mechanical equipment.
 - 3. Wiring from motors to disconnect switches or junction boxes for motors of mechanical equipment, but only where specifically indicated to be furnished integrally with equipment.
 - 4. Wiring of field-mounted float control switches, flow control switches, and similar mechanical-electrical devices provided for mechanical systems, to equipment control panels.
- C. Refer to requirements of Division-26 sections.

1.2 QUALITY ASSURANCE

- A. Coordination with Electrical Work: Wherever possible, match elements of electrical provisions of mechanical work with similar elements of electrical work specified in Division-26 sections for electrical work of this section which is not otherwise specified.
- B. Standards: For electrical equipment and products, comply with applicable NEMA standards, and refer to NEMA standards for definitions of terminology herein. Comply with National Electrical Code (NFPA 70) for workmanship and installation requirements.

1.3 SUBMITTALS

- A. Listing, Motors of Mechanical Work: Concurrently, with submittal of mechanical products listing (Basic Mechanical and Division-1 requirements), submit separate listing showing rating, power characteristics, application (connected equipment), and general location of every motor to be provided with mechanical work. Submit updated information promptly when and if initial data is revised.
 - 1. Include in listing of motors, notations of whether motor starter is furnished or installed integrally with motor or equipment containing motor.

PART 2 - PRODUCTS

2.1 MOTORS

- A. Motor Characteristics: Except where more stringent requirements are indicated, and except where required item of mechanical equipment cannot be obtained with fully complying motor, comply with the following requirements for motors of mechanical work:
- B. Temperature Rating: Rated for 113 degrees F (40 degrees C) environment with maximum 122 degrees F (50 degrees C) temperature rise for continuous duty at full-load (Class B Insulation).
- C. Starting Capability: Provide each motor capable of making starts as frequently as indicated by automatic control system, and not less than five (5) starts per hour for manually controlled motors.
- D. Phases and Current Characteristics: Provide squirrel cage induction polyphase motors for 1/2 hp (.4 kW) and larger, and provide capacitor-start single-phase motors for 1/3 hp (.25 kW) and smaller, except 1/6 hp (.1 kW) and smaller may, at equipment manufacturer's option, be split-phase type. Coordinate current characteristics with power specified in Division-26 sections, and with individual equipment requirements specified in other Division-23 requirements. For 2-speed motors provide two (2) separate windings on polyphase motors. Do not purchase motors until power characteristics available at locations of motors have been confirmed, and until rotation directions have been confirmed.
- E. Service Factor: 1.15 for polyphase motors and 1.35 for single-phase motors.
- F. Motor Construction: Provide general purpose, continuous duty motors, Class F insulation, Design "B" except "C" where required for high starting torque.
 - 1. Bearings: Ball or roller bearings with inner and outer shaft seals, regreasable except permanently sealed where motor is normally inaccessible for regular maintenance. Where belt drives and other drives produce lateral or axial thrust in motor, provide bearings designed to resist thrust loading. Refer to individual sections of Division-23 for fractional-hp light-duty motors where sleeve-type bearings are permitted.
 - 2. Enclosure Type: Except as otherwise indicated, provide open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation, and provide guarded drip-proof motors where exposed to contact by employees or building occupants. Provide weather-protected Type I for outdoor use, Type II where not housed. Refer to individual sections of Division-23 for other enclosure requirements.
 - 3. Overload Protection: Provide built-in thermal overload protection and, where indicated, provide internal sensing device suitable for signaling and stopping motor at starter.

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4. Noise Rating: Provide industry standard "Quiet" rating on motors.
5. Efficiency: For motors 1 horsepower (.7 kW) or higher, provide motors with minimum efficiencies as follows in accordance with IEEE Standard 112, Test Method B:

a. Open Motors (ODP)

MOTOR HP (KW)	MINIMUM EFFICIENCY *		
	<u>1200 RPM</u>	<u>1800 RPM</u>	<u>3600 RPM</u>
1 (.7)	82.5%	85.5%	77.0%
1.5 (1.1)	86.5%	86.5%	84.0%
2 (1.5)	87.5%	86.5%	85.5%
3 (2.2)	88.5%	89.5%	85.5%
5 (4)	89.5%	89.5%	86.5%
7.5 (5.6)	90.2%	91.0%	88.5%
10 (8)	91.7%	91.7%	89.5%
15 (11)	91.7%	93.0%	90.2%
20 (15)	92.4%	93.0%	91.0%
25 (19)	93.0%	93.6%	91.7%
30 (22)	93.6%	94.1%	91.7%
40 (30)	94.1%	94.1%	92.4%
50 (38)	94.1%	94.5%	93.0%

* Required Full Load Nominal Efficiency shall be in accordance with EISA 2007. Where efficiency listed above is higher than the EISA 2007 requirement, provide the higher efficiency indicated.

b. Enclosed Motors (TEFC)

MOTOR HP (KW)	MINIMUM EFFICIENCY *		
	<u>1200 RPM</u>	<u>1800 RPM</u>	<u>3600 RPM</u>
1 (.7)	82.5%	85.5%	77.0%

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	1.5 (1.1)	87.5%	86.5%	84.0%
	2 (1.5)	88.5%	86.5%	85.5%
	3 (2.2)	89.5%	89.5%	86.5%
	5 (4)	89.5%	89.5%	88.5%
	7.5 (5.6)	91.0%	91.7%	89.5%
	10 (8)	91.0%	91.7%	90.2%
	15 (11)	91.7%	92.4%	91.0%
	20 (15)	91.7%	93.0%	91.0%
	25 (19)	93.0%	93.6%	91.7%
	30 (22)	93.0%	93.6%	91.7%
40 (30) 94.5%	94.1% 93.0%	94.1% 60 (45)	92.4% 94.5%	50 (38) 95.0%
				94.1% 93.6%

* Required Full Load Nominal Efficiency shall be in accordance with EISA 2007. Where efficiency listed above is higher than the EISA 2007 requirement, provide the higher efficiency indicated.

- c. Where fan or pump motors are used in conjunction with, or controlled by, a variable frequency drive (VFD), motors shall be suitable for VFD operation (inverter duty motors).
- d. For motors less than 1 horsepower (.7 kW), provide motors with higher efficiency than "average standard industry motors," in accordance with IEEE Standard 112, test method B.
- G. Nameplate: Provide metal nameplate on each motor, indicating full identification of manufacturer, ratings, characteristics, construction, special feature and similar information.
- H. Motor Modifications: In cases where the equipment submitted requires additional motors and/or controls, circuiting and related equipment shall be provided as approved and in accordance with the National Electrical Code. All costs relative to these electrical changes shall be included under the Section in which the equipment is furnished and installed and shall be coordinated with the electrical work at no expense to the Owner.
- I. Power Factor: All motors one (1) horsepower and above shall have a minimum power factor of 0.90.
- J. All motors operated on variable frequency drives shall be equipped with a maintenance free, conductive microfiber, shaft grounding ring with a minimum of two (2) rows of

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circumferential microfibers to discharge electrical shaft currents within the motor and/or its bearings. Motors up to 100 HP shall be provided with a minimum of one (1) shaft grounding ring installed either on the drive end or non-drive end. Grounding rings shall be provided and installed by the motor pump manufacturer or contractor and shall be installed in accordance with the manufacturer's recommendations.

2.2 MOTOR STARTERS AND VARIABLE FREQUENCY DRIVES (VFDS)

- A. Where motor starters and/or variable frequency drives (VFD's) are indicated for mechanical equipment, they shall comply with all requirements outlined with the electrical specifications for motor starters and VFD's. Where motor starters and/or VFD's are provided by the mechanical contractor, or as a portion of a packaged mechanical unit, the electrical specifications shall also apply. All VFD's for the project, whether provided by the mechanical or electrical contractor, shall be provided by a single manufacturer, and shall include the same features and options.

2.3 MECHANICAL EQUIPMENT

- A. The rooftop air handling unit electrical components shall have an overall short circuit withstand rating of at least 65,000 Ampere Interrupting Capacity and be UL listed as such.
- B. All mechanical equipment shall be approved and listed by Underwriters' Laboratories (UL) and shall bear nameplate indicating same.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install motors on motor mounting systems in accordance with motor manufacturer's instructions, securely anchored to resist torque, drive thrusts, and other external forces inherent in mechanical work. Secure sheaves and other drive units to motor shafts with keys and Allen set screws, except motors of 1/3 hp (.25 kW) and less may be secured with Allen set screws on flat surface of shaft. Unless otherwise indicated, set motor shafts parallel with machine shafts.
- B. Deliver starters and wiring devices which have not been factory installed on equipment unit to electrical Installer for installation.
- C. Install furnished under Division-26 starter panels and wiring devices at locations indicated, securely supported and anchored, and in accordance with manufacturer's installation instructions. Locate in accordance with National Electric Code for installation requirements.

END OF SECTION 230513

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SECTION 230514 - PIPE, TUBE AND FITTINGS FOR HVAC SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of pipes and pipe fittings required by this section is indicated on drawings and/or specified in all other Division-23 sections.
- B. Types of pipes and pipe fittings specified in this section include the following:
 - 1. Steel Pipes
 - 2. Copper Tube
- C. Refer to requirements of Division-26.

1.2 QUALITY ASSURANCE

- A. Codes and Standards:
 - 1. Welding: Qualify welding procedures, welders and operators in accordance with ASME B31.1, or ASME B31.9, as applicable, for shop and project site welding of piping work.
 - a. Certify welding of piping work using the Standard Procedure Specifications by, and welders tested under supervision of, National Certified Pipe Welding Bureau (NCPWB).
 - 2. Brazing: Certify brazing procedures, brazers and operators in accordance with ASME Boiler and Pressure Vessel Code, Section IX, for shop and job-site brazing of piping work.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of pipe and pipe fitting. In addition, submit a matrix indicating each service and the proposed pipe material and fitting.
- B. Welding Certifications: Submit reports as required for piping work.
- C. Brazing Certifications: Submit reports as required for piping work.
- D. Maintenance Data: Submit maintenance data and parts lists for each type of mechanical fitting. Include this data, product data, and certifications in maintenance manual; in accordance with requirements of Division-1.

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1.4 DELIVERY, STORAGE AND HANDLING

- A. Provide factory-applied plastic end-caps on each length of pipe and tube. Maintain end-caps through shipping, storage and handling as required to prevent pipe-end damage, and eliminate dirt and moisture from inside of pipe and tube.
- B. Where possible, store pipe and tube inside and protected from weather. Where necessary to store outside, elevate above grade and enclose with durable, waterproof wrapping.
- C. Protect flanges and fittings from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Piping Materials: Provide pipe and tube of type, joint type, grade, size and weight (wall thickness or Class) indicated for each service; where type, grade or class is not indicated. Provide proper selection as determined by Installer for installation requirements, and comply with governing regulations and industry standards.
- B. Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve or equipment connection in each case. Where not otherwise indicated, comply with governing regulations and industry standards for selections, and with pipe manufacturer's recommendations where applicable.

2.2 STEEL PIPES AND PIPE FITTINGS

- A. Black Steel Pipe: ASTM A 53, A 106 or A 120; except comply with ASTM A 53 or A 106 where close coiling or bending is required.
- B. Wrought-Steel Butt welding Fittings: ANSI B16.9, except ANSI B16.28 for short-radius elbows and returns; rated to match connected pipe.

2.3 COPPER TUBE AND FITTINGS

- A. Copper Type: ASTM B 88; Type (wall thickness) as indicated for each service; hard-drawn temper, except as otherwise indicated.
- B. ACR Copper Tube: ASTM B 280.
- C. Wrought-Copper Solder-Joint Fittings: ANSI B16.22.
- D. Copper-Tube Unions: Provide standard products recommended by manufacturer for use in service indicated.

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2.4 MISCELLANEOUS PIPING MATERIALS/PRODUCTS

- A. Welding Materials: Except as otherwise indicated, provide welding materials as determined by Installer to comply with installation requirements.
 - 1. Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials.
- B. Soldering Materials: Except as otherwise indicated, provide soldering materials as determined by Installer to comply with installation requirements.
 - 1. Tin-Antimony Solder: ASTM B 32, Grade 95TA.
 - 2. Silver Solder: ASTM B 32, Grade 96TS.
- C. Brazing Materials: Except as otherwise indicated, provide brazing materials as determined by Installer to comply with installation requirements.
 - 1. Comply with SFA-5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials.
- D. Gaskets for Flanged Joints: ANSI B16.21; full-faced or cast-iron raised face for steel flanges, unless otherwise indicated.
- E. Piping Connectors for Dissimilar Non-Pressure Pipe: Elastomeric annular ring insert, or elastomeric flexible coupling secured at each end with stainless steel clamps, sized for exact fit to pipe ends.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently-leakproof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings, but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16" (1.6 mm) misalignment tolerance.
 - 1. Comply with ANSI B31 Code for Pressure Piping.
- B. Locate piping runs, except as otherwise indicated, vertically and horizontally (pitched to drain) and avoid diagonal runs wherever possible. Where trapping is unavoidable, install drain valve with 3/4" (20 mm) hose end connection, cap and chain. Provide access panels as required. Orient horizontal runs parallel with walls and column lines. Locate runs as shown or described by diagrams, details and notations or, if not otherwise indicated, run piping in shortest route which does not obstruct usable space or block access for servicing building and its equipment. Hold piping close to walls, overhead

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construction, columns and other structural and permanent enclosure elements of building; limit clearance to 1/2" (13 mm) where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any. Where possible, locate insulated piping for 1" (25 mm) clearance outside insulation. Wherever possible in finished and occupied spaces, conceal piping from view, by locating in column enclosures, in hollow wall construction or above suspended ceilings; do not encase horizontal runs in solid partitions, except as indicated.

- C. Exposed piping in finished areas shall be covered with a 16 gauge steel primed and painted metal cover, secured to an adjacent structure and painted to match adjacent surfaces.
- D. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures unless unavoidable. Install drip pan under piping that must be run through electrical spaces.

3.2 PIPING SYSTEM JOINTS

- A. General: Provide joints of type indicated in each piping system.
 - 1. Braze copper tube-and-fitting joints where indicated, in accordance with ASME B31.
 - 2. Solder copper tube-and-fitting joints where indicated, in accordance with recognized industry practice. Cut tube ends squarely, ream to full inside diameter, and clean outside of tube ends and inside of fittings. Apply solder flux to joint areas of both tubes and fittings. Insert tube full depth into fitting, and solder in manner which will draw solder full depth and circumference of joint. Wipe excess solder from joint before it hardens.
- B. Weld pipe joints in accordance with ASME Code for Pressure Piping, B31.
- C. Weld pipe joints in accordance with recognized industry practice and as follows:
 - 1. Weld pipe joints only when ambient temperature is above 0°F (-18°C) where possible.
 - 2. Bevel pipe ends at a 37.5° angle where possible, smooth rough cuts, and clean to remove slag, metal particles and dirt.
 - 3. Use pipe clamps or tack-weld joints with 1" (25 mm) long welds; 4 welds for pipe sizes to 10" (250 mm), 8 welds for pipe sizes 12" (300 mm) to 20" (500 mm).
 - 4. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes and non-metallic inclusions.
 - 5. Do not weld-out piping system imperfections by tack-welding procedures; refabricate to comply with requirements.

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6. At Installer's option, install forged branch-connection fittings wherever branch pipe is indicated; or install regular "T" fitting.
- D. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

3.3 PIPING INSTALLATION

- A. All piping shall be installed level, plumb, and square relative to the adjacent building structure.
- B. Group piping, where practical, and install from common supports.

3.4 RADIOGRAPHIC (X-RAY) TESTING

- A. Field weld joints for all black steel pipe shall be radiographically (x-ray) tested to the extent identified below.
- B. Testing shall be conducted by an independent testing company. The testing company shall provide arrest report identifying the results of each weld tested (pass/fail).
- C. The Contractor shall engage the Owner and Engineer of Record to identify welds to be tested.
- D. Testing:
 1. If the total quantity of field welds is greater than 50, test 10% of field welds.
 2. If the total quantity of field welds is less than 50, test 25% of field welds.
 3. Should any of the initial welds tested fail, Contractor will be required to test an additional 20% of all remaining welds, at no additional cost to the Owner.
 4. Should any of the additional 20% of welds tested fail, Contractor will be requested to test 100% of all remaining welds, at no additional cost to the Owner.

3.5 CLEANING, FLUSHING, INSPECTING

- A. General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any). Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports and accessory items.
 1. Inspect pressure piping in accordance with procedures of ASME B31.
- B. Disinfect water mains and water service piping in accordance with AWWA C601.

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3.6 PIPE TESTING

- A. Refer to Division-23 section "Testing, Adjusting and Balancing" for pipe testing requirements.

END OF SECTION 230514

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SECTION 230515 - PIPING SPECIALTIES FOR HVAC SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of piping specialties work required by this section is indicated on drawings and schedules and by requirements of this section.
- B. Types of piping specialties specified in this section include the following:
 - 1. Pipe Escutcheons
 - 2. Pipeline Strainers
 - 3. Dielectric Fittings
 - 4. Mechanical Sleeve Seals
 - 5. Penetration Seals
 - 6. Drip Pans
 - 7. Pipe Sleeves
 - 8. Sleeve Seals
 - 9. Flexible Connectors
- C. Piping specialties furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-23 sections.
- D. Refer to requirements of Division-26.

1.2 QUALITY ASSURANCE

- A. Codes and Standards:
 - 1. FCI Compliance: Test and rate "Y" type strainers in accordance with FCI 73-1 "Pressure Rating Standard for "Y" Type Strainers". Test and rate other type strainers in accordance with FCI 78-1 "Pressure Rating Standard for Pipeline Strainers Other than "Y" Type".

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions, and dimensioned drawings for each type of manufactured piping specialty.

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Include pressure drop curve or chart for each type and size of pipeline strainer. Submit schedule showing manufacturer's figure number, size, location, and features for each required piping specialty.

- B. Shop Drawings: Submit for fabricated specialties, indicating fabrication, materials, and method of support.
- C. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured piping specialty. Include this data, product data, and shop drawings in maintenance manual.

PART 2 - PRODUCTS

2.1 PIPING SPECIALTIES

- A. General: Provide factory-fabricated piping specialties recommended by manufacturer for use in service indicated. Provide piping specialties of types and pressure ratings indicated for each service, or if not indicated, provide proper selection to comply with installation requirements. Provide sizes as indicated, and connections, which properly mate with pipe, tube, and equipment connections.

2.2 PIPE ESCUTCHEONS

- A. General: Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.
- B. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged.
- C. Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.

2.3 LOW PRESSURE Y-TYPE PIPELINE STRAINERS

- A. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125 psi (850 kPa) working pressure, with Type 304 stainless steel screens, with perforations as follows:
 1. Piping 2" (50 mm) and Smaller: 1/32" (.8 mm) diameter perforations.
 2. Piping 2-1/2" (65 mm) and Larger: 3/64" (1.2 mm) diameter perforations for water systems.
- B. Threaded Ends, 2" (50 mm) and Smaller: Brass body, screwed screen retainer with

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- centered blowdown fitted with valve and pipe plug.
- C. Threaded Ends, 2-1/2" (65 mm) and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with valve and pipe plug.
 - D. Flanged Ends, 2-1/2" (65 mm) and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with valve and pipe plug.
 - E. Butt Welded Ends, 2-1/2" (65 mm) and Larger: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with valve and pipe plug.
 - F. Grooved Ends, 2-1/2" (65 mm) and Larger: Tee pattern, ductile-iron or malleable-iron body and access end cap, access coupling with EDPM gasket.

2.4 HIGH PRESSURE Y-TYPE PIPELINE STRAINERS

- A. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 250 psi (1724 kPa) working pressure, with Type 304 stainless steel screens, with 3/64" (1.2 mm) perforations @ 233 per sq. in.
- B. Threaded Ends, 2" (50 mm) and Smaller: Cast-iron body, screwed screen retainer with centered blowdown fitted with valve and pipe plug.
- C. Threaded Ends, 2-1/2" (65 mm) and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with valve and pipe plug.
- D. Flanged Ends 2-1/2" (65 mm) and Larger: Cast-iron body, bolted steel retainer with off-center blowdown fitted with valve and pipe plug.
- E. Butt Welded Ends, 2-1/2" (65 mm) and Larger: Schedule 80 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with valve and pipe plug.

2.5 DIELECTRIC FITTINGS

- A. General: Provide assembly or fitting having insulating material to isolate dissimilar metals to prevent galvanic action and stop corrosion.
 - 1. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - a. Provide separate companion flanges and steel bolts and nuts for 150- or 300-psig (1035 kPa or 2070 kPa) minimum working pressure to suit system pressures.
 - 2. Dielectric Nipples: Electroplated steel nipple, having inert and non-corrosive thermoplastic lining, with combination of plain, threaded, or grooved end types and 300-psig (2070 kPa) working pressure at 225°F (107°C) temperature.

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3. Dielectric unions shall NOT be acceptable.

2.6 MECHANICAL SLEEVE SEALS

- A. General: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

2.7 PENETRATION SEALS

- A. Provide seals for all openings through fire-rated walls, floors, or ceilings used as passage for mechanical piping. See Division-23 Section "Basic HVAC Materials and Methods" for penetration seals and firestopping requirements.
- B. Provide seals for all openings through walls, floors or ceilings used as passage for mechanical components such as piping.

2.8 FABRICATED PIPING SPECIALTIES

- A. Drip Pans: Provide drip pans fabricated from corrosion-resistant sheet metal with watertight joints, and with edges turned up 2-1/2" (65 mm). Reinforce top, either by structural angles or by rolling top over 1/4" (6 mm) steel rod. Provide hole, gasket, and flange at low point for watertight joint and 1" (25 mm) drain line connection.
- B. Pipe Sleeves: Provide pipe sleeves of one of the following:
 1. Sheet-Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate from the following gages: 3" (75 mm) and smaller, 20 gage (1.0 mm); 4" to 6" (100 mm to 150 mm), 16 gage (1.6 mm); over 6" (150 mm), 14 gage (2 mm).
 2. Steel-Pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs.
 3. Iron-Pipe: Fabricate from cast-iron or ductile-iron pipe; remove burrs.

2.9 FLEXIBLE CONNECTORS

- A. Furnish and install braided stainless steel flexible connectors on the inlet and outlet of each pump, chiller, cooling tower, and all other piping connected to a vibrating piece of equipment. Construction shall be of annular corrugated stainless steel close-pitch hose with stainless steel overbraid.
 1. The corrugated metal hose, braids, and a stainless steel ring-ferrule/band (material gauge not less than .048") (material gauge not less than 1.2 mm) shall be integrally welded using a 100% circumferential, full-penetration TIG weld.
 2. End fittings shall be flat-face plate steel flanges with 150#ANSI drilling and outside

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- diameter. Fittings shall be attached using a 100% circumferential TIG/MIG weld.
3. Braided stainless steel connectors shall be suitable for operating temperatures up to 850°F (454°C).
 4. The rated working pressure of braided metal hose shall have a minimum 4:1 safety factor based on an operating temperature of 70°F (20°C). Each braided stainless steel connector shall be individually leak tested by the manufacturer using air-under-water or hydrostatic pressure.
 5. Flanged connectors shall be prepared for shipment using cut-to-length spacers, securely positioned between the flanges to prevent axial compression damage and maintain the manufactured length. Spacers must be removed prior to system start-up.
 6. All braided stainless steel connectors shall be covered by a three (3) year warranty.
 7. Minimum overall lengths shall be as follows:

Through 4" (100 mm) diameter:	9" (225 mm)
5" (125 mm), 6" (150 mm) diameter:	11" (275 mm)
Over 6" (150 mm) diameter:	1.5 times nominal diameter

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

- A. Pipe Escutcheons: Install pipe escutcheons on each pipe penetration thru floors, walls, partitions, and ceilings where penetration is exposed to view; and on exterior of building. Secure escutcheon to pipe or insulation so escutcheon covers penetration hole, and is flush with adjoining surface.
- B. Y-Type Strainers: Install Y-type strainers full size of pipeline, in accordance with manufacturer's installation instructions. Install pipe nipple and shutoff valve in strainer blow down connection, full size of connection, except for strainers 2" (50 mm) and smaller installed ahead of control valves feeding individual terminals. Where indicated, provide drain line from shutoff valve to drain, full size of blow down connection.
 1. Locate Y-type strainers ahead of the following equipment, and elsewhere as indicated, if integral strainer is not included in equipment:
 - a. Pumps
 - b. Temperature control valves
 - c. Pressure reducing valves
 - d. Temperature or pressure regulating valves

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- C. Dielectric Fittings: Install at each piping joint between ferrous and non-ferrous piping. Comply with manufacturer's installation instructions.
- D. Mechanical Sleeve Seals: Provide mechanical sleeve seals for sleeves located in foundation walls below grade, or in exterior walls. Loosely assemble rubber links around pipe with bolts and pressure plates located under each bolt head and nut. Push into sleeve and center. Tighten bolts until links have expanded to form watertight seal.

3.2 INSTALLATION OF FABRICATED PIPING SPECIALTIES

- A. Drip Pans: Locate drip pans under piping passing over or within 3' (0.9 m) horizontally of electrical equipment, and elsewhere as indicated. Hang from structure with rods and building attachments, weld rods to sides of drip pan. Brace to prevent sagging or swaying. Connect 1" (25 mm) drain line to drain connection, and run to nearest drain as indicated.
- B. Pipe Sleeves: Install pipe sleeves of types indicated where piping passes through walls, floors, ceilings, and roofs. Do not install sleeves through structural members of work, except as detailed on drawings, or as reviewed by the Owner. Install sleeves accurately centered on pipe runs. Size sleeves so that piping and insulation (if any) will have free movement in sleeve, including allowance for thermal expansion; but not less than two (2) pipe sizes larger than piping run. Where insulation includes vapor-barrier jacket, provide sleeve with sufficient clearance for installation. Install length of sleeve equal to thickness of construction penetrated, and finish flush to surface; except floor sleeves. Sleeves through floors shall be flush with the floor, except for sleeves passing through equipment rooms, toilet rooms (and other wet areas) which shall extend 3/4" (20 mm) above the floor. Space between the pipe and sleeve shall be caulked. Escutcheons plates shall be constructed to conceal the ends of sleeves. Extend floor sleeves 1/4" (6 mm) above level floor finish and 3/4" (20 mm) above floor finish sloped to drain. Provide temporary support of sleeves during placement of concrete and other work around sleeves, and provide temporary closure to prevent concrete and other materials from entering sleeves.
 - 1. Install sheet-metal sleeves at interior partitions and ceilings other than suspended ceilings.
 - 2. Install iron-pipe sleeves at exterior and interior foundation wall penetrations, both above and below grade. Penetrations shall be sealed weathertight.
 - 3. Install steel-pipe except as otherwise indicated.

3.3 INSTALLATION OF FLEXIBLE PIPE CONNECTORS

- A. Provide flexible pipe connectors on the inlet and outlet of each pump, chiller, cooling tower and all other piping connected to a vibrating piece of equipment. Flexible connectors shall be full line size as indicated on the drawings and should be provided with control rods.

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SECTION 230516 - EXPANSION COMPENSATION FOR HVAC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of expansion compensation products required by this section is indicated on drawings and/or specified in other Division-23 sections.
- B. Types of expansion compensation products specified in this section include the following:
 - 1. Packless Expansion Joints:
 - a. Expansion Compensators
- C. Expansion compensation products furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division-23 sections.

1.2 QUALITY ASSURANCE

- A. Codes and Standards:
 - 1. EJMA Compliance: Construct compensation products in accordance with standards of the Expansion Joint Manufacturer's Association (EJMA).

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of expansion compensation product. Submit expansion compensation schedule showing manufacturer's figure number, size, location, and features for each required expansion compensation product.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of expansion compensation product, indicating dimensions, weights, required clearances, and methods of assembly of components.
- C. Shop Drawings: Submit shop drawings for fabricated expansion loops indicating location, dimensions, pipe sizes, and location and method of attachment of anchors.
- D. Maintenance Data: Submit maintenance data and spare parts lists for each type of expansion compensation product. Include this data, product data, and shop drawings in maintenance manual.

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PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include the following:
 1. Flexonics Inc., Metal Hose and Expansion Joint Div.
 2. Keflex HVAC Products, Flex-Weld, Inc.
 3. Metraflex Co.
 4. Mason Industries, Inc.
 5. Vibration Mountings and Controls, Subsidiary of ARX.

2.2 PACKLESS EXPANSION JOINTS

- A. General: Provide packless expansion joints where indicated for piping systems, with materials and pressure/temperature ratings selected by installer to suit intended service. Select packless expansion joints to provide 200% absorption capacity of piping expansion between anchors.
- B. Expansion Compensators: Pressure rated for 60 (415 kPa) psi for low pressure systems, 175 psi (1200 kPa) for high pressure systems; 2-ply phosphor bronze bellows, brass shrouds and end fittings for copper piping systems, or 2-ply stainless steel bellows, carbon steel shrouds and end fittings for steel piping systems. Provide internal guides and anti-torque device, and removable end clip for proper positioning.

2.3 MISCELLANEOUS MATERIALS

- A. Pipe Alignment Guides: Provide factory-fabricated guides, of cast semi-steel or heavy fabricated steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which expansion compensation products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

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3.2 EXPANSION JOINTS

- A. General: Install expansion joints where indicated, and elsewhere as required for adequate expansion of installed piping system. Install in accordance with manufacturer's instructions. Provide pipe anchors and pipe alignment guides as indicated, and in accordance with manufacturer's recommendations. Align units properly to avoid end loading and torsional stress.

3.3 EXPANSION LOOPS

- A. General: Fabricate expansion loops as indicated, in locations indicated, and elsewhere as required for adequate expansion of installed piping system. Subject loop to cold spring which will absorb 50% of total expansion between hot and cold conditions. Provide pipe anchors and pipe alignment guides as required to properly anchor piping in relationship to expansion loops.

3.4 EXPANSION COMPENSATION FOR RISERS AND TERMINALS

- A. General: Install connection between piping mains and risers with at least five (5) pipe fittings including tee in main. Install connections between piping risers and terminal units with at least four (4) pipe fittings including tee in riser.

3.5 INSTALLATION OF ANCHORS

- A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ANSI B31, and to prevent transfer of loading and stresses to connected equipment.
- B. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure. Comply with ANSI B31 and with AWS standards.
- C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.
- D. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principle pipe-runs, at intermediate points in pipe-runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

END OF SECTION 230516

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SECTION 230519 - METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of meters and gauges required by this section is indicated on drawings and/or specified in other Division-23 sections.
- B. Types of meters and gauges specified in this section include the following:
 - 1. Temperature Gauges and Fittings:
 - a. Direct Mount Dial Thermometers
 - b. Thermometer Wells
 - 2. Pressure Gauges and Fittings:
 - a. Pressure Gauges
 - b. Pressure Gauge Cocks
 - c. Pressure Gauge Connector Plugs
 - d. Magnehelic Pressure Gauges
 - 3. Flow Measuring Meters:
 - a. Flow Meter Fittings
 - b. Flow Measuring Readout Kit
- C. Meters and gauges furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division-23 sections.

1.2 QUALITY ASSURANCE

- A. Codes and Standards:
 - 1. UL Compliance: Comply with applicable UL standards pertaining to meters and gauges.
 - 2. ANSI and ISA Compliances: Comply with applicable portions of American National Standards Institute (ANSI) and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gauges.
- B. Certification: Provide meters and gauges whose accuracies, under specified operating

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conditions, are certified by manufacturer.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of meter and gauge. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gauge schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gauge.
- B. Maintenance Data: Submit maintenance data and spare parts lists for each type of meter and gauge. Include this data in Maintenance Manual.

PART 2 - PRODUCTS

2.1 DIRECT MOUNT DIAL THERMOMETERS

- A. General: Provide direct mount dial thermometers of materials designed and constructed for use in service indicated.
- B. Type: Vapor tension, universal angle.
- C. Case: Drawn steel or brass, glass lens, 5" (125 mm) diameter. For gauges mounted above eight feet (2400 mm), 8" (200 mm) diameter gauge.
- D. Adjustable Joint: Die cast aluminum, 180 degree adjustment in vertical plane, 360 degree adjustment in horizontal plane, with locking device.
- E. Thermal Bulb: Copper with phosphor bronze bourdon pressure tube, one scale division accuracy.
- F. Movement: Brass precision geared.
- G. Scale: Progressive, satin faced, non-reflective aluminum, permanently etched markings.
- H. Stem: Copper plated steel, or brass, for separable socket, length to suit installation.
- I. Range: Conform to the following:
 1. Hot Water: 30°F - 240°F (-1°C - 116°C).
 2. Chilled Water: 30°F - 120°F (-1°C - 49°C).
 3. Air: 40°F - 160°F (4°C - 71°C).

2.2 THERMOMETER WELLS

- A. General: Provide thermometer wells constructed of brass or stainless steel, pressure

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rated to match piping system design pressure. Provide 2" (50 mm) extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.

- B. Manufacturer: Same as thermometers.

2.3 PRESSURE GAUGES

- A. General: Provide pressure gauges of materials designed and constructed for use in service indicated.
- B. Type: General use, 1% accuracy, ANSI B 40.1 Grade A, phosphor bronze bourdon type, bottom connection.
- C. Case: Drawn steel or brass, glass lens, 5" (125 mm) diameter. For gauges mounted above eight feet (2400 mm), 8" (200 mm) gauges shall be used.
- D. Connector: Brass with 1/4" (6 mm) male NPT.
- E. Scale: White coated aluminum, with permanently etched markings.
- F. Range: Conform to the following:
 - 1. Water: 0 - 100 psi (0 - 690 kPa).

2.4 PRESSURE GAUGE COCKS

- A. General: Provide pressure gauge cocks between pressure gauges and gauge tees on piping systems. Construct gauge cock of brass with 1/4" (6 mm) female NPT on each end, and "T" handle brass plug.
- B. Syphon: 1/4" (6 mm) straight coil constructed of brass tubing with 1/4" (6 mm) male NPT on each end.
- C. Snubber: 1/4" (6 mm) brass bushing with corrosion resistant porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served and pressure rating.
- D. Manufacturer: Same as for pressure gauges.

2.5 PRESSURE GAUGE CONNECTOR PLUGS

- A. General: Provide pressure gauge connector plugs pressure rated for 500 psi (3448 kPa) and 200°F (93°C). Construct of brass and finish in nickel plate, equip with 1/2" (13 mm) NPS fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8" (3 mm) O.D. probe assembly from dial type insertion pressure gauge. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.

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2.6 MAGNEHELIC PRESSURE GAUGES

- A. Provide direct reading magnehelic gauges indicating pressure drop across each filter assembly. The inlet and outlet of filter assembly shall be provided with remote dial type gauges of suitable ranges.

2.7 FLOW METER FITTINGS

- A. Furnish and install venturi flow metering elements at each balancing valve location indicated on plans and drawings. Elements 2" (50 mm) and smaller shall be constructed of brass with threaded connections, 2-1/2" (65 mm) and larger shall be constructed of steel with butt weld or flanged connections.
- B. Each primary element shall be selected to permit the design flow rate to fall between 20% to 80% of the full range on the linear scale of the meter. The permanent pressure loss shall not exceed 10% of the indicated flow rate differential.
- C. The accuracy shall be $\pm 3\%$ of flow rate in the flow range indicated on the tabulation as verified by a recognized Independent Laboratory specializing in the research, testing and application of fluid meters, valves and hydraulics.
- D. Each element shall be complete with instrument shut-off valves each with quick disconnect connections and identification tag with a chain, pressure rated to 300 psi (2069 kPa), temperature rated to 250°F (121°C).
- E. Flow meter fittings shall be as manufactured by Preso, Flow Design or Flowset.

2.8 FLOW MEASURING READOUT KIT

- A. Provide portable flow meters with bellows type differential pressure element and minimum 5" (125 mm) diameter indicating dial.
- B. Design pressure elements for full scale pressure differential of 50" or 100" water gauge (12.4 kPa or 24.9 kPa). Design shall incorporate rupture-proof metal beryllium or stainless steel bellows and torque tube drive requiring no lubrication. Design forged bodies for not less than 150% of maximum surge pressure, fully protected against surges, with full provision for venting and draining. Provide integral, adjustable pulsation dampers.
- C. Dials of portable meters shall have square root scales not less than 12" (300 mm) in developed length. Dials shall read from 0 to 10 gpm (0 to .6 L/s) to which multiplier is to be applied, as required; also provide with uniform scale reading from 0" to 10" w.g. (0 kPa to 2.5 kPa), to which multiplier of 10 is to be applied (100" at full scale) (2.5 m at full scale), or from 0" to 5" w.g. (0 kPa to 1.2 kPa), to which multiplier of 10 is to be applied (50" at full scale) (2.5 m at full scale).
- D. Engineer and manufacture in accordance with ASME recommendations for flow meters. Provide portable meters with overall accuracy of $\pm 5\%$.

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- E. Provide flow meter with factory-fabricated carrying case with integral carrying handle. Case shall be fitted to hold meter and following accessories:
1. Two 10' (3 m) lengths of connecting hose with suitable female connectors for connecting to venturi tube pressure tap nipples. Design hose for operating pressure of minimum of 150% of maximum system operating pressure.
 2. Completely assembled 3-valve manifold with 2 block valves and vent and drain valves shall be piped and mounted on base, which shall be designed for use laying flat on stationary base.
 3. Bound set of descriptive bulletins, installation and operating instructions, parts list, and set of curves showing flow verses pressure differential for each orifice or venturi tube with which meter is to be used.
 4. Metal instruction plate, secured inside cover, illustrating use of meter. Deliver meter with case to Owner.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which meters and gauges are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF TEMPERATURE GAUGES

- A. General: Install temperature gauges in vertical upright position, and tilted so as to be easily read by observer standing on floor.
- B. Locations: Install direct mounted thermometers in the following locations, and elsewhere as indicated:
1. At inlet and outlet of each hydronic zone.
 2. At inlet and outlet of each hydronic coil in air handling units. At suction and discharge of each hydronic pump.
 3. Supply, return, fresh air and mixed air for each air handling unit.
- C. Thermometer Wells: Install in piping tee where thermometers are indicated, in vertical upright position. Fill well with oil or graphite, secure cap.

3.3 INSTALLATION OF PRESSURE GAUGES

- A. General: Install pressure gauges in piping tee with pressure gauge cock, located on pipe at most readable position.

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- B. Locations: Install in the following locations, and elsewhere as indicated:
 - 1. At suction and discharge of each pump.
 - 2. At inlet and outlet of each pressure reducing valve.
 - 3. At inlet and outlet of large strainers.
 - 4. At inlet and outlet of each coil.
- C. Pressure Gauge Cocks: Install in piping tee with snubber.
- D. Pressure Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.

3.4 ADJUSTING AND CLEANING

- A. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.
- B. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked or broken windows and repair any scratched or marred surfaces with manufacturer's touch-up paint.

END OF SECTION 230519

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SECTION 230523 - VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of valves required by this section is indicated on drawings and/or specified in other Division-23 sections.
- B. Types of valves specified in this section include the following:
 - 1. Drain Valves
 - 2. Ball Valves
 - 3. Butterfly Valves
 - 4. Check Valves
- C. System Descriptions:
 - 1. HVAC Piping: HVAC piping shall relate to chilled water and heating water systems.
- D. Valves furnished as part of factory-fabricated equipment, are specified as part of the equipment assembly in other Division-23 sections.

1.2 QUALITY ASSURANCE

- A. Valve Types: Provide valves of same type by same manufacturer.
- B. Valve Identification: Provide valves with manufacturer's name (or trademark) and pressure rating and size clearly marked on valve body.
- C. Codes and Standards:
 - 1. MSS Compliance: Mark valves in accordance with MSS-25 "Standard Marking System for Valves, Fittings, Flanges and Unions".
 - 2. ANSI Compliance: For face-to-face and end-to-end dimensions of flanged or welded-end valve bodies, comply with ANSI B16.10 "Face-to-Face and End-to-End Dimensions of Ferrous Valves".

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of valve. Include pressure drop curve or chart for each type and size of valve. Submit valve schedule showing manufacturer's figure number, size,

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- location, and valve features for each required valve.
- B. Shop Drawings: Submit manufacturer's assembly-type (exploded view) shop drawings for each type of valve, indicating dimensions, weights, materials, and methods of assembly of components.
 - C. Maintenance Data: Submit maintenance data and spare parts lists for each type of valve. Include this data, product data, and shop drawings in Maintenance Manual.

PART 2 - PRODUCTS

2.1 VALVES - GENERAL

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work, shall be limited to the following, unless otherwise noted:
 - 1. Milwaukee
 - 2. Bray
 - 3. Apollo
 - 4. DeZurik
 - 5. Jamesbury
 - 6. Watts
- B. Provide factory-fabricated valves recommended by manufacturer for use in service indicated. Provide valves of types and pressure ratings indicated; provide proper selection as determined by Installer to comply with installation requirements. Provide end connections which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option.
- C. Size: Unless otherwise indicated, provide valves of same size as upstream pipe size. Pipe size reduction shall be made after valve assembly.
- D. Valve Features: Provide the following as required:
 - 1. General: Provide valves with features indicated and, where not otherwise indicated, provide proper valve features as determined by Installer for installation requirements. Comply with ASME B31.9 for building services piping, and ASME B31.1 for power piping.
 - 2. Bypass: Comply with MSS SP-45, and except as otherwise indicated, provide manufacturer's standard bypass piping and valving.
 - 3. Drain: Comply with MSS SP-45, and provide threaded pipe plugs.

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4. Flanged: Valve flanges complying with ANSI B16.1 (cast iron), ANSI B16.5, (steel), or ANSI B16.24 (bronze).
5. Threaded: Valve ends complying with ANSI B2.1.
6. Butt-Welding: Valve ends complying with ANSI B16.25.
7. Socket-Welding: Valve ends complying with ANSI B16.11.
8. Solder-Joint: Valve ends complying with ANSI B16.18.
9. Flangeless: Valve bodies manufactured to fit between flanges complying with ANSI B16.1 (cast iron), ANSI B16.5 (steel), or ANSI B16.24 (bronze).
10. Operators: Provide handwheels, fastened to valve stem, for valves other than quarter-turn. Provide lever handle for quarter-turn valves 6" (150 mm) and smaller. Provide gear operators for quarter-turn valves 8" (200 mm) and larger. Provide chain-operated sheaves and chains for overhead valves as indicated.

2.2 GATE VALVES

- A. Comply with the following standards:
 1. Cast-Iron Valves: MSS SP-70.
 2. Bronze Valves: MSS SP-80.
 3. Steel Valves: ANSI B16.34.

2.3 DRAIN VALVES

- A. HVAC, Piping:
 1. 3" (75 mm) and Smaller: Class 125, bronze body ball valve with chrome plated ball, hose end with cap and chain. Milwaukee BA100H (Threaded), Milwaukee BA150H (Sweat) or equivalent.

2.4 BALL VALVES

- A. Comply with the following standards:
 1. Bronze Valves: MSS SP-110.
 2. Potable Water: NSF-61-8.
- B. HVAC, Piping:
 1. 2" (50 mm) and Smaller: Valves shall be rated 150 psi (1035 kPa) SWP and 600 psi (4140 kPa) non-shock WOG and shall have 2-piece cast ASTM B 584 bronze

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bodies, TFE seats, standard port, separate packing nut with adjustable stem packing, anti-blowout stems and stainless steel ball. Valve ends shall have full depth ANSI threads or extended solder connections and be manufactured to comply with MSS-SP110. Milwaukee BA100S (Threaded), BA150S (Sweat) or equivalent with NSF compliance for potable water.

- C. Where piping is insulated, ball valves shall be equipped with 2" (50 mm) extended handles of non-thermal conductive material. Also, provide a protective sleeve that allows operation of the valve without breaking the vapor seal or disturbing the insulation. Memory stops, which are fully adjustable after insulation is applied, shall be included.

2.5 BUTTERFLY VALVES

- A. General: Comply with MSS SP-68. Where butterfly valves are used as shutoffs for terminal or equipment removal or repair, select bubble tight, lug body type valves suitable for dead end service.
- B. HVAC Piping:
 1. 2-1/2 " (65 mm) to 6" (150 mm): 150 psi (1035 kPa), carbon steel or 316 stainless steel body, extended neck, 316 stainless steel disc, single piece RPTFE seat with stainless steel spring insert, self-lubricating bearings, double shaft and manual lever and lock. Milwaukee Model HP1LCS4212 or equivalent.
 2. 8" (200 mm) and Larger: 150 psi (1035 kPa), carbon steel or 316 stainless steel body, extended neck, 316 stainless steel disc, single piece RPTFE seat, self-lubricating bearings, double offset shaft, manual lever and lock and gear operator. Milwaukee Model HP1LCS4213 or equivalent.
 3. All valves shall be capable of bubble tight dead end service in either direction without use of additional pinning, screws or mating flanges.
 4. Valves shall have pressure energized type seats of RPTFE with seat energizing insert. EPDM rubber seats are not acceptable. Seats shall be field replaceable.
 5. Provide packing gland with "V" type ring packing, externally adjustable. Packing gland, nuts and studs shall be constructed of stainless steel.

2.6 CHECK VALVES

- A. Comply with the following standards:
 1. Cast-Iron Valves: MSS SP-71.
 2. Bronze Valves: MSS SP-80.
 3. Steel Valves: ANSI B16.34.
- B. HVAC Piping:

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1. 2" (50 mm) and Smaller: Class 150, bronze body, horizontal swing, T pattern with renewable TFE disc. Milwaukee 510T (Threaded), 1510T (Sweat) or equivalent.
2. 2-1/2" (65 mm) and Larger: Class 125, iron body, bolted bonnet, horizontal swing, renewable seat and disc, flanged ends. Milwaukee F2974A or equivalent.

2.7 BALANCE VALVES

- A. HVAC: See Division-23 section "Hydronic Specialties" for HVAC balance valve specification, however all valves shall meet the requirements of this Section.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Except as otherwise indicated, comply with the following requirements.
1. Install valves where required for proper operation of piping and equipment, including valves in branch lines, service mains and all equipment connections. Locate valves so as to be accessible and so that separate support can be provided when necessary.
 2. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane unless unavoidable. Install valve drains with hose-end adapter for each valve that must be installed with stem below horizontal plane.
- B. Insulation: Where insulated, install extended-stem valves, arranged in proper manner to receive insulation.
- C. Mechanical Actuators: Install mechanical actuators with chain operators where indicated. Extend chains to approximately five feet (1500 mm) above floor and secure to clips to clear aisle passage.
- D. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select and install valves with connections to match pipe fittings.
- E. Renewable Seats: Install valves with renewable seats, where applicable.
- F. Fluid Control: Except as otherwise indicated, install gate, ball, globe, and butterfly valves to comply with ANSI B31.9. Where throttling is indicated or recognized as principle reason for valve, install ball, globe or butterfly valves, as indicated.
- G. Installation of Check Valves: Install in horizontal position with hinge pin horizontally perpendicular to center line of pipe. Install for proper direction of flow.

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3.2 ADJUSTING AND CLEANING

- A. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.
- B. Valve Identification: Tag each valve in accordance with Division-23 section "Identification for HVAC Piping and Equipment".
- C. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION 230523

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SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of hangers and supports required by this section is indicated on drawings and/or specified in other Division-23 sections.
- B. Types of hangers and supports specified in this section include the following:
 - 1. Horizontal-Piping Hangers and Supports
 - 2. Vertical-Piping Clamps
 - 3. Hanger-Rod Attachments
 - 4. Building Attachments
 - 5. Saddles and Shields
 - 6. Spring Hangers and Supports
 - 7. Miscellaneous Materials
 - 8. Roof Equipment Supports
 - 9. Anchors
 - 10. Equipment Supports
- C. Hangers and supports furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division-23 sections.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of hangers and supports, of types and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Codes and Standards:
 - 1. Code Compliance: Comply with applicable codes pertaining to product materials and installation of hangers and supports.
 - 2. NFPA, UL, and FM Compliance: Provide products which comply with NFPA 13 listed and labeled by UL and FM where used for fire protection piping systems.

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3. MSS Standard Compliance:

- a. Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-58.
- b. Select and apply pipe hangers and supports, complying with MSS SP-69.
- c. Fabricate and install pipe hangers and supports, complying with MSS SP-89.
- d. Terminology used in this section is defined in MSS SP-90.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing manufacturer's figure number, size, location, and features for each required pipe hanger and support.

PART 2 - PRODUCTS

2.1 HORIZONTAL-PIPING HANGERS AND SUPPORTS

- A. General: Except as otherwise indicated, provide factory-fabricated horizontal-piping hangers and supports complying with MSS SP-58, selected by Installer to suit horizontal-piping systems in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hangers and supports to exactly fit pipe size for bare piping, and to exactly fit around piping insulation with saddle or shield for insulated piping. Provide copper-plated hangers and supports for copper-piping systems. To avoid future electrolysis or corrosion, copper plated hangers, supports, clamps, rod attachments, and building attachments shall not be in direct contact with copper piping. A separation material shall be installed between the pipe and the copper plated hanger, support, clamp, etc. The separation material shall prohibit electrical conductance and prevent galvanic action or corrosion between dissimilar metals. Separation material shall be guaranteed for a minimum of thirty (30) years.

2.2 VERTICAL-PIPING CLAMPS

- A. General: Except as otherwise indicated, provide factory-fabricated vertical-piping clamps complying with MSS SP-58, selected by Installer to suit vertical piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Provide copper-plated hangers and supports for copper-piping systems. To avoid future electrolysis or corrosion, copper plated hangers, supports, clamps, rod attachments, and building attachments shall not be in direct contact with copper piping. A separation material shall be installed between the pipe and the copper plated hanger, support, clamp, etc. The

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separation material shall prohibit electrical conductance and prevent galvanic action or corrosion between dissimilar metals. Separation material shall be guaranteed for a minimum of thirty (30) years.

2.3 HANGER-ROD ATTACHMENTS

- A. General: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments complying with MSS SP-58, selected by Installer to suit horizontal-piping hangers and building attachments, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hanger-rod attachments to suit hanger rods. Provide copper-plated hanger-rod attachments for copper-piping systems. To avoid future electrolysis or corrosion, copper plated hangers, supports, clamps, rod attachments, and building attachments shall not be in direct contact with copper piping. A separation material shall be installed between the pipe and the copper plated hanger, support, clamp, etc. The separation material shall prohibit electrical conductance and prevent galvanic action or corrosion between dissimilar metals. Separation material shall be guaranteed for a minimum of thirty (30) years.

2.4 BUILDING ATTACHMENTS

- A. General: Except as otherwise indicated, provide factory-fabricated building attachments complying with MSS SP-58, selected by Installer to suit building substrate conditions, in accordance with MSS SP-69 and manufacturer's published product information. Select size of building attachments to suit hanger rods. Provide copper-plated building attachments for copper-piping systems. Provide copper-plated hangers and supports for copper-piping systems. To avoid future electrolysis or corrosion, copper plated hangers, supports, clamps, rod attachments, and building attachments shall not be in direct contact with copper piping. A separation material shall be installed between the pipe and the copper plated hanger, support, clamp, etc. The separation material shall prohibit electrical conductance and prevent galvanic action or corrosion between dissimilar metals. Separation material shall be guaranteed for a minimum of thirty (30) years.

2.5 SADDLES AND SHIELDS

- A. General: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.

2.6 SPRING HANGERS AND SUPPORTS

- A. General: Except as otherwise indicated, provide factory-fabricated spring hangers and supports complying with MSS SP-58, selected by Installer to suit piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select spring hangers and supports to suit pipe size and loading.

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2.7 MISCELLANEOUS MATERIALS

- A. Metal Framing: Provide products complying with NEMA STD ML 1.
- B. Steel Plates, Shapes and Bars: Provide products complying with ASTM A 36.
- C. Cement Grout: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2).
- D. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which hangers and supports are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF BUILDING ATTACHMENTS

- A. Install attachments at required locations within concrete or steel for proper piping support. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert securely to forms. Where concrete with compressive strength less than 2500 psi (17240 kPa) is indicated, install reinforcing bars through openings at top of inserts.

3.3 INSTALLATION OF HANGERS AND SUPPORTS

- A. General: Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Install supports with maximum spacings complying with MSS SP-69. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.
- B. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.
- C. Support fire-water piping independently of other piping.
- D. Prevent electrolysis in support of copper tubing by use of hangers and supports which

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are copper plated, or by other recognized industry methods.

E. Provisions for Movement:

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

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

G. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31 Pressure Piping Codes are not exceeded.

H. Insulated Piping: Comply with the following installation requirements.

1. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ANSI B31.

2. Shields: Where low-compressive-strength insulation or vapor barriers are indicated on chilled water piping, install coated protective shields.

3. Saddles: Where insulation without vapor barrier is indicated, install protection saddles.

4. For all insulated piping 2-1/2" (63 mm) and larger, provide insulated saddles as follows:

a. For chilled water and heating water, provide the following:

- 1) Minimum 3.5 pcf, non-compressive, rigid, phenolic foam insulation. Fire and smoke rating shall be 25/50 or below per ASTM 84.

- 2) For cold applications below 75°F (24°C) a zero permeability abuse resistant vapor barrier shall be provided with matching butt strips. Apply a full coating of butyl joint sealant in addition to the butt strips for a completely sealed system.

- 3) The phenolic foam system shall have a K factor of 0.16 at a mean temperature for 75°F (24°C) and comply with ASTM Standard C1126.

- 4) Provide visible inspection sticker at the bottom of each saddle.

- 5) Pipe insulation saddles shall be Tru-Balance CoolDry Saddles as manufactured by Buckaroos, Inc. or equivalent.

I. Spacing: Hanger spacing for piping shall not exceed 8 feet (2400 mm) on centers for pipe 1-1/4" (32 mm) or smaller, and 10 feet (3 m) for pipe 1-1/2" (40 mm) and larger. Regardless of spacing, hangers shall be provided at or near all changes in direction, both vertical and horizontal, for all piping. For cast iron soil pipe, one hanger shall be

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placed at each hub or bell.

3.4 ADJUSTMENT OF HANGERS AND SUPPORTS

- A. Adjust hangers and supports and place grout as required under supports to bring piping to proper levels and elevations.

3.5 EQUIPMENT SUPPORTS

- A. Provide concrete housekeeping bases for all floor mounted equipment furnished as part of the work of Division-23. Size bases to extend minimum of 4" (100 mm) beyond equipment base in any direction; and 4" (100 mm) above finished floor elevation. Construct of reinforced concrete, roughen floor slab beneath base for bond, and provide steel rod anchors between floor and base. Locate anchor bolts using equipment manufacturer's templates. Chamfer top and edge corners.
- B. Provide structural steel stands to support equipment not floor mounted or hung from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks mounted on steel stands.

3.6 PAINTING

- A. All hangers, supports, clamps and assemblies shall be primed and painted with rust inhibitors.

END OF SECTION 230529

SECTION 230548 - VIBRATION ISOLATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Scope: The extent of vibration isolation work to be provided under this Contract is covered by the requirements of this Section, all other Division-23 sections and the Contract Drawings including structural, architectural, mechanical and electrical which identify equipment and systems requiring vibration isolation treatment.
- B. Types: Types of vibration isolation equipment and systems specified in this Section include:

<u>TYPE</u>	<u>DESCRIPTION</u>
1 Isolator	Ribbed Neoprene Pads
2I Isolator	Neoprene-In-Shear Type
2H Hanger	Rubber-In-Shear Type
3I Isolator	Open Spring Type
3H Hanger	Combination Spring and Neoprene Type
4 Isolator	Vertically Restrained Spring Isolators
5 Thrust	Restraints Spring Type Installed in Pairs
A Base	Directly Bolted Attachment
B Base	Structural Rails or Bases
C Base	Concrete Inertia Type

- C. Selection of Isolators: Provide isolators selected by a vibration isolator equipment specialist.
 1. Conform to isolator types herein specified.
 2. Examine the contract drawings for sizes, horsepowers, rotational speeds, equipment location, length of span between columns and beams and construction type to determine the isolator selection type and deflection required for each piece of mechanical equipment.
 3. Conform to the requirements of the most current edition of American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Handbook, "HVAC Applications", Sound and Vibration Control.

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1.2 QUALITY ASSURANCE

- A. Codes: At a minimum, conform to the most current edition of ASHRAE Handbook, "HVAC Applications".
- B. Manufacturer: Isolators of the same type shall be the product of the same manufacturer. The manufacturer shall publish and maintain a full line of materials, engineering and application data and operating and maintenance instructions.

1.3 SUBMITTALS

- A. Contractor's Certification: Vibration isolator submittals shall include a certification, signed by an officer representing the Contractor and stipulating that the submittal prepared by the manufacturer has been reviewed, and checked on an item by item basis against each piece of mechanical equipment, shown or specified in the Contract Documents, which requires vibration isolation.
- B. Manufacturer's Certification: The manufacturer or manufacturers (if there are more than one) shall each certify that the selections of vibration isolation equipment are based upon the drawings and specifications, and that each piece of mechanical equipment has been examined for rotational speed, equipment type, mounting location, and supporting span between column centers, and that an appropriate isolator has been selected.
- C. Product Data: Furnish manufacturer's product data covering each isolator type for style, characteristic, and finish.
 - 1. Isolator quantities, dimensions, deflections, capacities and types shall remain the responsibility of the manufacturer and the Contractor.
- D. Shop Drawings: Where coordinated shop drawings are required, provide layout drawings, drawn to a scale of not less than 1/4-inch to 1-foot (6 mm to 300 mm), showing the proposed layout of equipment and piping systems and the location and type of each vibration isolation device.
 - 1. Carefully examine other sections requiring coordinated shop drawings and prepare isolation shop drawings to the same scale showing the location of each vibration isolation equipment base, pipe hanger, flexible connection, and isolator.

1.4 STORAGE AND PROTECTION

- A. Storage: Store vibration isolation equipment indoors in the manufacturer's original shipping containers. Preclude the entrance of construction dirt and debris.
 - 1. Vibration isolation equipment and bases, which show signs of rust, cement or concrete fouling, dirt and construction debris shall be disassembled and cleaned, approved or removed from the project site and replaced with new.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include the following:
1. Mason
 2. Vibration Eliminator Co.
 3. Kinetics Noise Control

2.2 EQUIPMENT

- A. Dimensions: The schedule shows dimensions for deflection and sizes all in inches.
- B. Spans: Where referenced, the schedule shows spans of the longest bay dimension for slabs or beams supported between columns. Dimensions are in feet.
- C. Selection: Exact mounting sizes, dimensions and quantity of isolators and static deflection required shall be determined by the isolator manufacturer based upon equipment that will be furnished and installed by the Contractor under this Contract.
1. Vibration isolation specialist shall coordinate his work with that of other trades to verify that equipment speeds, in revolutions per minute (rpm), are based upon actual equipment installed at the project site.
 2. Verify that equipment rpm and spring deflection selected are arranged so that resonance is avoided.

2.3 ISOLATOR TYPES

- A. Type 1 Isolators: Provide pad type vibration isolators consisting of either two layers of 3/8-inch (10 mm) thick elastomer, molded to contain a pattern with non-slip characteristics in all directions, and bonded to 16 gauge (1.6 mm) galvanized steel separator plates, or 1-inch (25 mm) thick precompressed molded fiberglass isolation pads. Minimum overall thickness shall be 1-inch (25 mm). Deflection shall be limited to 0.25 inches (6 mm) or less. Loading shall not exceed 40 pounds per square inch (280 kPa).
- B. Type 2I Isolators: Provide double rubber-in-shear or elastomer-in-shear with molded-in steel reinforcement in the top and bottom portions.
1. Deflections shall be limited to 0.5 inches (13 mm) or less.
 2. Steel bases shall be drilled with mounting holes and equipment mounting points shall be threaded male or female connections.

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3. Treat resilient material with antiozone and antioxidant additives.
- C. Type 2H Hangers: Provide rubber-in-compression suspension hangers, consisting of a formed steel frame and elastomer isolation element and provided with attachments for top and bottom suspension rods.
 1. Design for a minimum 200 percent overload without noticeable deformation or failure.
 2. Metal components shall be galvanized or factory painted.
- D. Type 3I Isolators: Provide adjustable, freestanding, open spring isolators with combination leveling and equipment fastening bases.
 1. Spring elements shall be contained in upper and lower housing assemblies and shall have a minimum Kx-Ky of 0.75.
 2. Design springs for a minimum travel of 50 percent beyond the rated load.
 3. When fully compressed and "bottomed-out", isolators shall be capable of supporting a 150 percent overload without deformation and spring failure.
 4. A minimum 1/4-inch (6 mm) thick non-skid isolation pad shall be bonded to the underside of the base plate.
 5. Size base plates to limit floor loading to 100 pounds per square inch (690 kPa).
 6. Drill base plates for bolting, as required.
 7. Provide means for anchoring the top element of the isolator to rails and equipment.
- E. Type 3H Hangers: Provide combination spring and elastomer hangers consisting of a formed steel frame with coil spring and elastomer insert in compression.
 1. Design hangers to be capable of supporting a 200 percent overload without noticeable deformation or failure.
 2. Design hangers to allow a 30 degree misalignment without binding or a reduction in hanger efficiency.
 3. Design hangers for connection to equipment and supporting rods.
- F. Type 4 Isolators: Provide vertically restrained, freestanding, laterally stable, open spring type isolators.
 1. Design for deflection exceeding 1/2-inch (13 mm).
 2. Provide built-in bearing and leveling provisions.
 3. Provide a minimum 1/4-inch (6 mm) thick non-slip elastomer vibration absorbing pad bonded to the underside of the isolator base.

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4. Outside diameter of each spring shall be equal to or greater than 0.9 times the operating height of the spring under rated load.
 5. Provide vertical limit stops to prevent hyperextension due to wind loads or upward movement when the load is removed. Limit stops shall not bind or inhibit spring movement during normal operating ranges.
 6. For exterior applications, steel housings shall be hot dipped galvanized and springs shall be neoprene or powder coated.
- G. Type 5 Thrust Restraints: Provide spring isolators of an adjustable, freestanding type enclosed within tubular mountings and arranged to be installed in pairs across the discharge of fan flexible connectors.
1. Design restraints to resist the thrust caused by duct internal air pressure.
 2. Install restraints on duct systems with an internal static pressure exceeding 3 inches water gauge (750 Pa).
 3. Restraints shall have the same deflection as isolators installed under the fans.

2.4 BASE TYPES

- A. Type A Bases: No supplementary base is required. Vibration isolators, specified elsewhere, shall be attached directly to the supported equipment or structural system.
- B. Type B, Structural Rails or Bases: Provide bases designed and supplied by the isolation equipment manufacturer.
 1. Construct bases of mill rolled structural sections of sufficient dimension to limit the midpoint deflection or unsupported spans to 1/1440th of the span between isolators.
 2. Include equipment static loadings, power transmission, component misalignment and cantilever loadings when designing structural sections.
 3. When head room is limited, coordinate the design of structural rails and isolators to reduce mounting heights.
 4. Factory finish with two (2) coats of equipment enamel.
- C. Type C, Concrete Inertia Bases: Provide concrete inertia bases designed by the isolator manufacturer and arranged to be filled with concrete in the field.
 1. Construct base of mill rolled structural steel sections, factory mitered and welded into a rigid frame and supporting No. 4 reinforcing bars welded to the structural frame 8 inches (200 mm) on centers both ways and located 2 inches (50 mm) from the bottom of the block.
 2. Arrange for outrigger isolation mountings, anchor bolts and equipment support.

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3. Field fill with 3,000 psi cured-strength concrete. Trowel to a smooth hard finish.
4. Clean structural steel of excess concrete and field paint all steel elements with two coats equipment enamel.
5. Configuration of inertia bases shall be rectangular to accommodate equipment supported unless otherwise indicated.
6. Minimum thickness of inertia bases, in addition to providing suitable mass, shall be sufficient to provide stiffness to maintain equipment manufacturer's recommended alignment and duty efficiency of power transmission.
7. Minimum thickness shall be sufficient to result in a base deflection at midpoint of unsupported span of not more than 1/1440th of the span between isolators.
8. Minimum thickness shall be 8 percent of the longest base dimension unless otherwise specified or indicated.
9. For centrifugal pumps, the bases shall be a minimum 6 inches (150 mm) thick.
10. Where inertia bases are used to mount pumps, the bases shall be long enough to support piping elbows for all connections.

2.5 PIPING AND DUCTWORK

- A. General: All ductwork and piping in mechanical equipment rooms and within fifty feet (15 m) of the vibration source (i.e. mechanical equipment such as air handling units, chillers, pumps, cooling towers, air compressors, etc.) shall be isolated from the building structure with flexible vibration isolators. Air handling units with less than two inches (500 Pa) of external static pressure shall be excluded from this requirement.
 1. Suspend ductwork on Type 3H hangers.
 2. Suspend piping on Type 3H hangers.
 3. Floor-mounted ductwork and piping shall be supported with Type 4 spring isolators with deflections the same as the equipment to which the piping is attached.
- B. Reciprocating Equipment: Provide spring type hangers with deflections equal to that of reciprocating equipment, with piping arranged with offset elbows to absorb vibration.
- C. Risers: Pipe and duct risers within 100 feet (30 m) of mechanical equipment rooms shall be resiliently anchored to the building structure with Type 1 vibration isolators, near the midpoint of the risers.
 1. Risers shall be isolated and supported at each second floor with pairs of Type 3H hangers, having deflections a minimum of five times the anticipated thermal movement at the support point.
 2. Risers shall be guided as required with four (4) sets of Type 2I vibration isolators.

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3. Provide flexible neoprene or canvas connectors as specified in sheet metal ductwork at the connection point to all air moving equipment.
4. Support ductwork with an internal pressure exceeding 3 inches (750 Pa) water with Type 3H hangers on maximum 10 foot (3 m) centers with deflections equal to the equipment isolators.

2.6 VIBRATION ISOLATION SYSTEM SELECTION

- A. General: The following selections of vibration isolation equipment systems shall be considered as a minimum. For the equipment below, the following code applies:

Letter (i.e. A, B, C) = Base type

Number (i.e. 1, 2, 3, 4) = Isolator type

Decimal number (i.e. 0.25, 1.5, etc.) = Minimum deflection

- B. Centrifugal Pumps:

- C. Air-Cooled Condensing Units:

20 FOOT (6 M) ROOF SPAN	30 FOOT (9 M) ROOF SPAN	40 FOOT (12 M) ROOF SPAN
A 2 0.25	A 2 0.35	A 2 0.5

- D. Low-Pressure AHU Locations (To 3-Inch W.G.) (750 Pa):

TYPE EQUIPMENT	20 FOOT (6M) FLOOR SPAN	30 FOOT (9 M) FLOOR SPAN	40 FOOT (12 M) FLOOR SPAN
Thru 10 hp (7.5 kW)	A 3 0.75	A 3 1.0	A 3 1.0
15 hp & over (11 kW & over) 250 to 500 rpm (26 to 52 Rad/s)	A 2 1.5	A 3 1.75	A 3 1.75
500 rpm (52 Rad/s)	A 3 1.0	A 3 1.5	A 3 1.75

Note: Where floor mounted air handling units are provided with internal vibration isolation for all vibration producing components, provide $\frac{3}{4}$ " neoprene pads.

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- E. Medium and High-Pressure AHU Locations (3-inch W.G. and above) (750 Pa and above):

TYPE EQUIPMENT	20 FOOT (6M) FLOOR SPAN	30 FOOT (9 M) FLOOR SPAN	40 FOOT (12 M) FLOOR SPAN
Thru 20 hp (Thru 15 kW) 300 to 500 rpm (Up to 52 Rad/s)	A 3 1.0	A 3 2.0	A 3 2.5
Over 20 hp (Over 15kW) 500 rpm and over (52 Rad/s and over)	A 3 1.5	A 3 1.5	A 3 2.5

- F. Note: Where floor mounted air handling units are provided with internal vibration isolation for all vibration producing components, provide 3/4" neoprene pads.

- G. Air Moving Device Locations:

- H. Vibration isolation provisions apply to housed or unhoused freestanding fans of any pressure rating, located in field-erected central-station units or in unhoused return air or supply air service.

TYPE EQUIPMENT	20 FOOT (6M) FLOOR SPAN	30 FOOT (9 M) FLOOR SPAN	40 FOOT (12 M) FLOOR SPAN
Up to 5 hp (Up to 3.7 kW)	B 3 1.0	B 3 1.0	B 3 1.5
5 thru 40 hp (3.7 thru 29.8 kW) 200 to 500 rpm (21 to 52 Rad/s)	B 3 1.5	B 3 1.5	B 3 2.5
500 rpm (52 Rad/s) & over)	C 3 0.75	C 3 1.5	C 3 2.5
Fan coil units, unit heaters	A 3 0.75	A 3 0.75	A 3 0.75

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PART 3 - EXECUTION

3.1 INSTALLATION

- A. Manufacturer: All vibration isolation equipment shall be installed in accordance with the manufacturer's recommendations.
- B. Manufacturer's Representative: The vibration isolation installation and deflection testing after equipment start-up shall be conducted by a representative of the manufacturer.

3.2 TESTS AND REPORTS

- A. Testing: Each vibration isolation device shall be deflection tested. Two (2) copies of a bound report shall be submitted prior to final acceptance. The certification shall include the following:
 1. Certify that equipment has been isolated in accordance with Contract Drawings, specifications and submittals.
 2. Certify that all minimum specified deflections have been equaled or exceeded.

3.3 ANCHORING

- A. Installation: Installation shall comply with manufacturer's published recommendations and shall be installed so that isolators are plumb and are operating at a manner for which they were designed.
 1. Unless otherwise specified, all equipment shall be securely bolted to isolators, steel bases or concrete inertia bases.
 2. Indoor vibration isolators need not be attached to the structure unless required by local codes.
 3. Isolators installed outdoors shall be attached to building structure.

3.4 CLEANING

- A. Debris: Remove all debris from under equipment, and thoroughly clean steel bases, inertia bases and check for free movement.
- B. Adjustment: Adjust isolators as required for proper operation prior to starting equipment. Testing of vibration isolators shall be performed by a certified representative of the manufacturer as specified.

3.5 GENERAL

- A. All exterior structural steel and/or steel housings of exterior vibration isolation materials

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shall be hot dipped galvanized.

END OF SECTION 230548

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SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of mechanical identification work required by this section is indicated on drawings and/or specified in other Division-23 sections.
- B. Types of identification devices specified in this section include the following:
 - 1. Pipe and Duct Markers
 - 2. Painted Identification Materials
 - 3. Valve Tags
 - 4. Valve Schedule Frames
 - 5. Engraved Plastic-Laminate Signs
 - 6. Ceiling Identification Markers
 - 7. Plastic Equipment Markers
 - 8. Plasticized Tags
- C. Refer to requirements of Division-26.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Codes and Standards:
 - 1. ANSI Standards: Comply with ANSI A13.1 or Owner standards for lettering size, length of color field, colors, and viewing angles of identification devices.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.
- B. Schedules: Submit valve schedule for each piping system, typewritten and reproduced on 8-1/2" x 11" (213 mm x 275 mm) bond paper. Tabulate valve number, piping system,

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system abbreviation (as shown on tag), location of valve (room or space), and variations for identification (if any). Mark valves which are intended for emergency shut-off and similar special uses, by special "flags", in margin of schedule. In addition to mounted copies, furnish extra copies for maintenance manuals.

- C. Maintenance Data: Include product data and schedules in maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers' products which may be incorporated in the work include the following:
1. Brady
 2. Seton
 3. Bunting

2.2 MECHANICAL IDENTIFICATION MATERIALS

- A. General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division-23 sections. Where more than single type is specified for application, selection is Installer's option but provide single selection for each product category.

2.3 PIPE AND DUCT MARKERS

- A. Snap-on Type: Provide pre-printed, semi-rigid, snap-on color coded identification sleeves complying with ANSI A13.1. This type shall be used for insulated pipe sizes 2" and smaller.
- B. Pressure Sensitive Type: Provide pre-printed, permanent adhesive, color coded, pressure sensitive, vinyl markers conforming to ANSI A13.1. This style marker shall be applied to all uninsulated piping; insulated piping 2-1/2" and larger, and all ductwork.
- C. Flow Direction: Provide flow directional arrows either as part of markers, or separately attached to pipes and ducts.

2.4 PAINTED IDENTIFICATION MATERIALS

- A. Piping and Equipment Systems: Continuous color coded painting of piping and equipment shall be provided in all mechanical rooms in compliance with ANSI A13.1.

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2.5 VALVE TAGS

- A. Brass Valve Tags: Provide 19-gage (1.2 mm) polished brass valve tags with stamp- engraved piping system abbreviation in 1/4" (6 mm) high letters and sequenced valve numbers 1/2" (13 mm) high, and with 5/32" (4 mm) hole for fastener.
 - 1. Provide 1-1/2" (40 mm) diameter tags, except as otherwise indicated.
- B. Valve Tag Fasteners: Provide manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.

2.6 VALVE SCHEDULE FRAMES

- A. General: For each page of valve schedule, provide glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with lexan.
 - 1. Locate one schedule where directed. Provide second schedule to Owner framed in rigid plastic frame with rigid plastic glazing.
 - 2. The frame shall include a floor plan with the locations of valves and room numbers.

2.7 ENGRAVED PLASTIC-LAMINATE SIGNS

- A. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in the sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black with white core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.
 - 1. Thickness: 1/16" (1.6 mm) for units up to 20 sq. in. (12900 mm²) or 8" (200 mm) length; 1/8" for larger units.
- B. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.
- C. Duty: Accident-prevention tags with appropriate wording including large-size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).

2.8 CEILING IDENTIFICATION TAGS

- A. Laminated plastic with adhesive back, engraved black letters on white background, minimum 0.5 inch (15 mm) wide and length as required for 0.375 inch (10 mm) high letters for name of concealed device and number. Tags shall be provided for valves and all other concealed HVAC equipment.

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2.9 PLASTIC EQUIPMENT MARKERS

- A. General: Provide manufacturer's standard laminated plastic, color coded equipment markers.
- B. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
 1. Name and schedule number
 2. Equipment service

2.10 LETTERING AND GRAPHICS

- A. General: Coordinate names, abbreviations and other designations used in mechanical identification work with corresponding designations shown on plans. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of mechanical systems and equipment.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 DUCTWORK IDENTIFICATION

- A. General: Identify air supply, return, exhaust, intake and relief ductwork with pressure sensitive markers and arrows, showing ductwork service and direction of flow.
- B. Location: In each space where ductwork is exposed, or concealed only by removable ceiling system, locate signs near points where ductwork originates or continues into concealed enclosures (shaft, underground or similar concealment), and at 25 foot (7500 mm) spacings.
- C. Access Doors: Provide duct markers on each access door in ductwork and housings, indicating purpose of access (to what equipment) and other maintenance and operating instructions, and appropriate safety and procedural information.

3.3 PIPING SYSTEM IDENTIFICATION

- A. General: Install pipe markers on each system indicated to receive identification, and include arrows to show normal direction of flow.

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- B. Locate pipe markers as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) exterior non-concealed, locations, and concealed gas piping.
1. Near each valve and control device.
 2. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
 3. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.
 4. Near major equipment items and other points of origination and termination.
 5. Spaced intermediately at maximum spacing of 25 feet (7500 mm) along each piping run.

3.4 VALVE IDENTIFICATION

- A. General: Provide valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory fabricated equipment units, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.
1. Tagging Schedule: Comply with requirements of "Valve Schedule" of this section.

3.5 MECHANICAL EQUIPMENT IDENTIFICATION

- A. General: Install engraved plastic laminate sign on or near each major item of mechanical equipment and each operational device, as specified herein if not otherwise specified for each item or device. Provide signs for the following general categories of equipment and operational devices:
1. Main control and operating valves.
 2. Pumps and similar motor driven units.
 3. Fans and blowers.
 4. Packaged HVAC central-station and air handling units.
- B. Lettering Size: Minimum 1/4" (6 mm) lettering for name of unit where viewing distance is less than 2'- 0" (600 mm - 0 mm), 1/2" (13 mm) high for distances up to 6'- 0" (1800 mm - 0 mm), and proportionately larger lettering for greater distances. Provide secondary lettering 2/3 to 3/4 of size of principal lettering.
- C. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

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3.6 ADJUSTING AND CLEANING

- A. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.
- B. Cleaning: Clean face of identification devices, and glass frames of valve charts.

3.7 EXTRA STOCK

- A. Furnish minimum of 5% extra stock of each mechanical identification material required, including additional numbered valve tags (not less than 3) for each piping system, additional piping system identification markers, and additional plastic laminate engraving blanks of assorted sizes.

3.8 IDENTIFICATION SCHEDULE

<u>SERVICE</u>	<u>DESIGNATION</u>
Chilled Water Supply	CWS
Chilled Water Return	CWR
Heating Water Supply	HS
Heating Water Return	HR

END OF SECTION 230553

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SECTION 230593 - TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of testing, adjusting, and balancing (TAB) work required by this section is indicated on drawings and schedules, and by requirements of this section, and is defined to include, but is not necessarily limited to, air distribution systems, hydronic distribution systems, and associated equipment and apparatus of mechanical work. The work consists of setting speed and volume (flow), adjusting facilities provided for systems, recording data, conducting tests, preparing and submitting reports to achieve the capacities or setpoints indicated on the contract documents, and recommending modifications to work as required to achieve the capacities or setpoints indicated on the contract documents.
- B. Component types of testing, adjusting, and balancing specified in this section shall include, but not be limited to, the following as applied to mechanical equipment:
 - 1. Building automated systems
 - 2. Fans
 - 3. Air handling units
 - 4. Ductwork systems
 - 5. Pumps
 - 6. Piping systems
 - 7. Terminal units
 - 8. Air devices
 - 9. Domestic hot water recirc pump and associated balance valves
- C. Refer to requirements of Division-26.
- D. See drawings for pre-demolition testing requirements (where applicable).

1.2 QUALITY ASSURANCE

- A. Tester's Qualifications: A firm certified by Associated Air Balance Council (AABC) who is not Installer of system to be tested.
 - 1. AABC Compliance: Comply with the current AABC's Manual "AABC National Standards", as applicable to mechanical air and hydronic distribution systems, and

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- associated equipment and apparatus.
2. Industry Standards: Comply with AABC recommendations pertaining to measurements, instruments, and testing, adjusting, and balancing, except as otherwise indicated.
 3. ASHRAE Standard 111: Comply with current edition of ASHRAE 111, "Measurement, Testing, Adjusting and Balancing of HVAC Systems".
 4. Independence: TAB contractor shall be independently owned and operated with no affiliation with the general contractor, mechanical contractor, sheet metal contractor, design engineer, etc.
 5. Experience: Each technician shall demonstrate a minimum of three years of actual test and balance field experience.
- B. Pipe Testing Procedures: Contractor shall pressure test all piping systems in accordance with the following:
1. ASME Code for Pressure Piping B31, most current edition.
 2. National Fire Protection Association (NFPA), all applicable sections, most current edition.
- 1.3 SUBMITTALS
- A. Qualification: TAB contractor qualifications shall be provided as a formal submittal for review to demonstrate conformance with all qualifications indicated throughout the contract documents.
 - B. Submit certified test reports, signed by the AABC Test and Balance technician who performed the TAB work. In addition, the report shall be certified by an AABC certified Test and Balance Engineer (T.B.E.) who is familiar with the project.
 1. Include identification and types of instruments used, and their most recent calibration date with submission of final test report.
 - C. The Contractor shall maintain a copy of AABC standards on the site during all TAB work. Said document(s) shall be made available to Owner representatives for reference as to minimum requirements.
 - D. Maintenance Data: Include in maintenance manuals, copies of certified test reports, identification of instruments.
- 1.4 JOB CONDITIONS
- A. Do not proceed with testing, adjusting, and balancing work until work has been completed, tested, operable, and all balancing devices indicated on the contract documents have been installed. Ensure that there is no residual work still to be

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- completed on the equipment to be tested.
- B. Do not proceed until work scheduled for testing, adjusting, and balancing is clean and free from debris, dirt and discarded building materials.

PART 2 - PRODUCTS

2.1 PATCHING MATERIALS

- A. Except as otherwise indicated, use same products as used by original Installer for patching holes in insulation, ductwork and housings which have been cut or drilled for test purposes, including access for test instruments, attaching jigs, and similar purposes.
1. Factory fabricated plastic plugs shall be used to patch drilled holes in ductwork and housings.

2.2 TEST INSTRUMENTS

- A. Utilize test instruments and equipment for TAB work required, of type, precision, and capacity as recommended in the following TAB standards:
1. AABC's Manual "AABC National Standards".
2. Wherever permanently installed measuring equipment is provided, such as air volume monitors, flow meters, temperature and pressure gages, etc., these shall be used in addition to TAB instrumentation. Any discrepancies in accuracy shall be brought to the attention of the Owner. Where permanently installed instrumentation meets accuracy requirements for TAB work, they may be used provided TAB Contractor can verify calibration of installed instruments.
- B. The Contractor shall employ manufactured enclosure type cones, capable of air volume direct readings, for all diffuser air flow measurements.

PART 3 - EXECUTION

3.1 FIELD WORK

- A. Prior to the mechanical installation, the mechanical and TAB contractors shall review the design documents for "balanceability" to confirm that all devices required to properly balance each system are to be provided under this contract. Recommended modifications and/or additions shall be made directly to the engineer and a minimum of 30 days prior to the installation of mechanical equipment.
- B. Examine installed work and conditions under which testing is to be done to ensure that work has been completed, cleaned, operable and accessible. Do not proceed with TAB work until unsatisfactory conditions have been corrected.

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- C. Test, adjust and balance environmental systems and components, as indicated, in accordance with procedures outlined in applicable AABC standards. All systems and components shall be balanced within ±5% of design air and water flows.
- D. Test, adjust and balance system during summer season for cooling and during winter season for heating systems, including operation at outside conditions within 3°F (2°C) wet bulb temperature of maximum summer design condition, and within 10°F (6°C) dry bulb temperature of minimum winter design condition. When seasonal operation does not permit measuring final temperatures, then take final temperature readings when seasonal operation does permit.
- E. For fan systems, provide sheave replacements where required to achieve specified air flows.
- F. Patch holes in insulation, ductwork and housings, which have been cut or drilled for test purposes, in manner recommended by original Installer.

3.2 REPORTS

- A. Prepare report of test results, including instrumentation calibration reports, in format recommended by AABC standards. Provide a System Summary page(s) at the front of the report.
- B. An interim/preliminary handwritten report shall be submitted to the Engineer for review prior to the formal submission of the report.
- C. Test reports shall include, but not be limited to, the following information:
 1. Air Handling Equipment Test:
 - a. Air handling equipment shall include, but not be limited to, all fans (supply, exhaust, return, relief, make-up, ventilation, etc.), air handling units, fan coil units, unit ventilators, VRF terminals, chilled beams. etc.).
 - b. Design Conditions: CFM, static pressure, motor h.p., outside air CFM (where applicable), fan and motor RPM and fan motor h.p. for each fan.
 - c. Installed Equipment: Manufacturer, size, arrangement, class, motor h.p., volts, phase, cycles, and full load amps.
 - d. Field Test Results: Fan CFM, fan RPM, fan motor voltage, fan motor operating amps, fan motor operating b.h.p., total static pressure for each fan. In addition, where applicable provide external static pressure, air pressure drop across each coil, filter bank, attenuator, etc. (ie. provide total static pressure profile of each system), as well as leaving air temperature, outside air conditions (dry bulb/wet bulb) at time of test, coil flow data (GPM), coil entering and leaving air temperatures, coil entering and leaving water temperatures, coil water pressure drop, VFD settings at final test conditions, and duct static pressure setpoint. Air temperature difference measurements will not be acceptable.

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2. Air Distribution Test: Main and major branch ducts and individual supply, return and exhaust terminals (VAV terminals, terminal reheat units, diffusers, registers and grilles):
 - a. Design Conditions: Ductwork: CFM, duct size. Air terminals, diffusers, registers, grilles: CFM, module size and inlet size.
 - b. Field Test Results: Ductwork: CFM, duct size, number of velocity readings, average velocity reading. Air terminals, diffusers, registers, grilles: CFM, module size and inlet size.
3. Pump Test:
 - a. Design Conditions: GPM, Head, RPM, motor h.p.
 - b. Installed Equipment: Manufacturer, size, type drive, motor h.p., volts, phase and cycles, full load amps.
 - c. Field Test Results: Shut-off head, discharge pressure, suction pressure, GPM, operating head, pump motor operating amps, pump motor operating b.h.p., VFD settings at final test conditions and differential pressure setpoint.
4. Miscellaneous Test Results:
 - a. All Coils: Air pressure drop, water pressure drop, water flow (GPM), air flow (CFM), entering water temperature, leaving water temperature, entering air temperature, leaving air temperature and outside air temperature at time of test (where applicable) and BTU calculations. Air temperature difference methods will not be acceptable.
 - b. Air Flow Monitors (AFM): Provide verification of AFM accuracy including set-up and adjustment required to verify proper operation and accuracy of each AFM system.
 - c. Sound Readings: Provide ten (10) sound power level readings at locations to be selected by the Engineer.
 - d. Balance Valves: All balance valves (including hydronic and domestic water) shall be adjusted and balanced to include water flow (GPM) and pressure drop (where applicable). Indicate manufacturer/model of each valve type.
- D. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced; including, where necessary, modifications which exceed requirements of contract documents for mechanical work.
- E. Record outdoor air temperature (dry bulb and wet bulb) at the time of testing air handling units, chillers, cooling towers, boilers and any other equipment where performance is affected by outdoor air conditions.
- F. Report shall include results of piping and ductwork tests indicated in paragraphs 3.03

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and 3.04 of this section.

3.3 TESTS - PIPING

- A. Prior to the balancing of systems by the AABC certified balancing contractor, the mechanical contractor shall air and/or hydrostatically test the following systems in accordance with the latest ASME B31 (ASME Code for Pressure Piping) and NFPA requirements.
 1. Air Test:
 - a. Refrigeration Liquid and Suction Line
 2. Hydrostatic Test:
 - a. Chilled/Heating Water Supply and Return Piping
- B. Pressure tests shall also be performed prior to the installation of all insulation materials.
- C. Hydrostatic Test: Provide temporary equipment for testing, including pump and gages. Test piping system before insulation is installed, wherever feasible and remove control devices before testing. Test each natural section of each piping system independently, but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with water and pressurize for indicated pressure and time.
 1. Required test period is four (4) hours.
 2. Hydrostatically test each piping system at 150% of operating pressure indicated, but not less than 100 psi (690 kPa) test pressure.
 3. Observe each test section for leakage at end of test period. Test fails if leakage is observed or if pressure drop exceeds one percent (1.0%) of test pressure.
 4. Upon completion of roughing-in and before setting fixtures, the entire new domestic water system shall be tested. Where a portion of the water piping system is to be concealed before completion, this portion shall be tested separately in a manner described for the entire system.
 5. Prior to testing, verify the pressures listed above are in accordance with the latest ASME B31 code and NFPA. Should a discrepancy exist between the ASME B31 code, NFPA, and/or the pressures indicated above, contact the Engineer prior to testing.
- D. Air Test:
 1. Refrigerant piping shall be air tested at 550 psi (3800 kPa) as follows:
 - a. Pressure Test (Air Tight Test): Pressurize the suction gas pipe, high/low pressure gas pipe and liquid pipe with dry nitrogen to a minimum pressure

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as per the system manufacturer. Pressure test duration shall be a minimum of 24 hours. If the pressure does not drop within the 24 hour period, the system passes. If there is a drop in pressure, check for leaks, make repairs and re-test as prescribed above.

- b. Evacuation Test (Vacuum Drying): Evacuate the system from the suction gas pipe, high/low pressure gas pipe and liquid pipe to a minimum vacuum pressure as per the system manufacturer. Vacuum pressure shall be maintained in accordance with manufacturer's minimum duration recommended. If it rises, the system may either contain moisture or have leaks, if so, make repairs and re-test as prescribed above.
- c. Refer to the Refrigerant Leakage Test Summary Form at the end of this section to document test results. No other form will be acceptable. Submit results for all systems for review.
- E. Repair or replace refrigerant piping as required to eliminate leaks, and retest as specified to demonstrate compliance.
- F. Refer to Division-23 section "Testing, Adjusting and Balancing" for additional specific test criteria and test form to be completed.
- G. Sanitary and Storm Water Piping Systems:
 - 1. All soil, waste, vent and storm water piping shall be tested by the Contractor and reviewed by the Architect before acceptance. All piping located underground shall be tested before backfilling. The costs of all equipment required for tests are to be included under the contract price.
 - 2. The entire new drainage system and venting system shall have all necessary openings plugged and filled with water to the level of the highest vent stack above the roof. The system shall hold this water for four (4) hours without showing a drop in water level. Where a portion of the system is to be tested, the test shall be conducted in the same manner as described for the entire system, except a vertical stack 10 feet (3000 mm) above the highest horizontal line to be tested may be installed and filled with water to maintain sufficient pressure, or a pump may be used to supply the required pressure.
- H. Drain test water from piping systems after testing and repair work has been completed.
- I. Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.
- J. Contractor shall submit piping leakage test results to the A/E within 72 hours of completed tests. Only test results that meet the specified leakage requirements shall be submitted. Piping test results shall be recorded on the "Piping Leakage Test Summary Form (Hydronic and Air)" and "Piping Leakage Test Summary Form (Plumbing)" located at the end of this section; no other forms will be accepted. In addition, the pipe leakage submittals shall include 11x17 drawing(s) as required to clearly indicate the full extent of the piping test section (each piping test section shall be numbered and color coded).

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3.4 TESTS - DUCTWORK

- A. Prior to the balancing of systems by the AABC certified balancing contractor, all high and low pressure systems shall be tested by the mechanical contractor for duct leakage. Duct leakage shall not exceed 1%. In addition, current SMACNA and AABC Standards shall apply, where applicable, to meet the maximum 1% leakage. Duct leakage shall not exceed 1% of design cfm for a duration of ten (10) minutes. Test pressures shall be not less than the following:

Ductwork systems less than 2.0 in. wg E.S.P.:

(Duct Pressure Class 2): Test to 2 in. wg

Ductwork systems between 2.0 in. wg and 5.0 in. wg E.S.P.:

(Duct Pressure Class 6): Test to 6 in. wg

Ductwork systems greater than 5.0 in. wg E.S.P.:

(Duct Pressure Class 10): Test to 10 in. wg

- B. Insulation materials shall not be applied until systems have been witnessed, documented, and submitted to meet the above testing requirements.
- C. The balance contractor shall witness and certify all duct pressure tests.
- D. Contractor shall submit duct leakage test results to the A/E within 72 hours of completed tests. Only test results that meet the specified leakage requirements shall be submitted. Duct test results shall be recorded on the attached "Air Duct Leakage Test Summary Form" at the end of this section; no other forms will be accepted. In addition, the duct leakage submittals shall include 11x17 drawing(s) as required to clearly indicate the full extent of the duct test section (each duct test section shall be numbered and color coded).
- E. All duct leakage test results shall be included with the final TAB report and the O&M manual. The orifice tube calibration chart shall also be included with the final duct leakage test report information.

3.5 TESTS - EQUIPMENT

- A. The contractor shall verify calibration of all indicating, recording, controlling and controlled devices throughout the mechanical system. Verify the proper function of all installed equipment and devices and the interlocking of all new systems as required by the contract documents.
- B. A report including successful calibration and function performance verification of all items indicated above shall be included in the Operations and Maintenance Manual.

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3.6 FUNCTIONAL PERFORMANCE TESTING AND VERIFICATION

- A. General: In addition to the tests required during and after installation of all mechanical systems, as well as any other formal commissioning requirements, the Contractor shall perform functional performance tests to verify that all systems are designed, installed, calibrated and adjusted to perform as required in the Contract.
- B. Comply with all applicable specification sections including, but not be limited to, "Basic HVAC Requirements", "Testing, Adjusting and Balancing", "Automatic Temperature Controls" and "Commissioning", where applicable.
- C. Prior to functional performance testing, all indicating, recording and control devices shall be calibrated. A verification calibration report shall be provided with the final test report.
- D. Provide functional performance testing to verify proper operation of each and every control sequence indicated throughout the contract documents.
- E. Failure of Tests: Should any test, verification, or demonstration fail to meet the specification requirements, the component of the system causing the failure shall be repaired, replaced or readjusted. The failed test, verification, or demonstration shall then be repeated.
- F. A "Functional Performance Test Verification Form" is included at the end of Section 230900. This form (electronic version is available upon request) shall be completed for all mechanical equipment provided under this contract. This shall include, but not be limited to each air handling unit, fan, pump, VAV terminal, DX cooling equipment, miscellaneous heating equipment, etc.
- G. Test Report: Upon satisfactory verification of calibration and functional performance tests, a copy of the final test results shall be bound in the operations and maintenance manual. The final report shall also include a full compliance statement, on company letterhead, indicating that all systems are installed and functioning per the contract requirements including drawings, specifications, control sequences and accepted submittals.
- H. The mechanical systems shall not be considered complete until all functional performance verification forms, calibration reports and compliance statement have been submitted and reviewed. Submit in accordance with the submittal requirements indicated elsewhere in these specifications.

3.7 FINAL TESTS, INSPECTION AND ACCEPTANCE

- A. At time of final inspection, Contractor shall recheck, in presence of Owner's Representative, random selections of data (water and air quantities, air motion, and sound levels) recorded in Certified Report. In addition, courtrooms, auditoriums, and conference rooms shall be rechecked. [Laboratories shall be rechecked for satisfactory air flow and motion in vicinity of and through hoods.]
 1. Points and areas for recheck shall be selected by Owner's Representative.

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2. Measurement and test procedures shall be same as approved for work forming basis of Certified Report.
 3. Selection for recheck (specific plus random), in general, will not exceed 25 percent of total number tabulated in report, except that special air systems may require a complete recheck for safety reasons.
- B. Retests: If random tests elicit a measured flow deviation of 10 percent or more from, or a sound level of 2 db or more, greater than that recorded in Certified Report listings, at 10 percent or more of the rechecked selections, report shall automatically be rejected. In the event the report is rejected, systems shall be readjusted and tested, new data recorded, new Certified Reports submitted, and new inspection tests made, at no additional cost to the Owner.
- C. Marking of Settings: Settings of valves, splitters, dampers, and other adjustment devices shall be permanently marked by the Contractor so that adjustment can be restored if disturbed at any time.

END OF SECTION 230593

AIR DUCT LEAKAGE TEST SUMMARY FORM

Project
Name: _____

Project Number: _____ Page _____ of _____

DESIGN DATA						FIELD TEST DATA RECORD								
Duct Test Section (No./Color)	Air System	Total System CFM	Test Section CFM	Allowable Leakage %	Allowable Leakage CFM	Diameter		Pressure (in. w.g.)		Actual Leakage CFM	Actual Leakage %	Test Result Pass/Fail	Test Performed By (initials)	Test Witnessed By (initials)
						Orifice	Tube	Duct(1)	Across Orifice					
				1.0%										
				1.0%										
				1.0%										
				1.0%										
				1.0%										
				1.0%										
				1.0%										
				1.0%										
				1.0%										
				1.0%										
				1.0%										
				1.0%										
				1.0%										

Testing Performed By:

(Company/Individual Name) _____

Witnessed/Certified By:

(Company/Individual Name) _____

(1) Duct test pressure shall be 6.0 in. w.g. for High/Medium Pressure ductwork, or 2.0 in. w.g. for Low Pressure ductwork.

PIPING LEAKAGE TEST SUMMARY FORM
(HYDRONIC AND AIR)

Project Name: _____ Project Number: _____ Page _____ of _____

System Tested	Sections Tested (1)	System Operating Pressure	Test Pressure (2)	Duration (3)	Pressure Drop (4)	Pass/Fail

Name of Testing Agency/Company:

Date of Test(s): _____

Test Conducted By (Print/Sign): _____

- (1) Identified by an 11 x 17 numbered and color coded test section plan. Plan shall accompany this test report.
- (2) 150% of operating pressure but not less than 100 psi (hydronic), and 400 psi (refrigerant).
- (3) Four (4) hours minimum.
- (4) Shall not exceed 0.0%.

PIPING LEAKAGE TEST SUMMARY FORM
(REFRIGERANT PRESSURE TEST)

Project Name: _____ Project Number: _____ Page _____ of _____

System/Unit Tested (1)	Test Location	Test Pressure (2)	Actual Test Pressure	Test Start			Test Completion			Pressure Drop (4)	Pass/Fail
				Time	Temperature	Pressure	Time	Temperature	Pressure		

Name of Testing Agency/Company: _____

Date of Test(s): _____

Test Conducted By (Print/Sign): _____

- (1) Equipment designation.
- (2) Per manufacturer's recommendation.
- (3) Twenty-four hours minimum from start to completion.
- (4) Shall not exceed 0.0%.

PIPING LEAKAGE TEST SUMMARY FORM

(PLUMBING)

Project Name: _____ Project Number: _____ Page _____ of _____

System Tested	Sections Tested (1)	System Operating Pressure	Test Pressure (PSI/FT-HD) (2)	Duration (3)	Pressure Drop (4)	Pass/Fail

Name of Testing Agency/Company: _____

Date of Test(s): _____

Test Conducted By (Print/Sign): _____

- (1) Identified by an 11 x 17 numbered and color coded test section plan. Plan shall accompany this test report.
- (2) 150% of operating pressure but not less than 100 psi , 200 psi for air-gas-vacuum, 10 ft. static head pressure or to the maximum rating of the joint. Include joint cut sheets showing their ratings.
- (3) Four (4) hours minimum.
- (4) Shall not exceed 0.0%.

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SECTION 230700 - HVAC INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of mechanical insulation required by this section is indicated on drawings and schedules, by requirements of this section, and all other Division-23 sections.
- B. Types of mechanical insulation specified in this section include the following:
 - 1. Piping System Insulation:
 - a. Fiberglass
 - b. Flexible Elastomeric
 - 2. Ductwork System Insulation:
 - a. Fiberglass
 - b. Flexible Elastomeric
 - c. Polyisocyanurate
 - 3. Equipment Insulation:
 - a. Fiberglass
 - b. Flexible Elastomeric

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of mechanical insulation products, of types and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Installer's Qualifications: Insulation installer shall be an independent sub-contractor (i.e. not the mechanical or plumbing contractor). Firms shall have at least five (5) years successful installation experience on projects with mechanical insulations similar to that required for this project. Provide installer's certification by the manufacturer's training program.
- C. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

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1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, k-value, thickness, and furnished accessories, and intended use for each mechanical system requiring insulation.
- B. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product data in maintenance manual.
- C. Installer's Qualifications: Provide qualifications on each installer indicating experience (i.e. number of years and project samples) and all pertinent certifications.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.
- B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work, shall be limited to the following:
 1. Owens Corning
 2. Johns Manville
 3. Certainteed
 4. Armacell
 5. Knauf
 6. Aeroflex

2.2 PIPE INSULATION MATERIALS

- A. Fiberglass Pipe Insulation: ASTM C 547, Type 1 (up to 850°F) (up to 454°C), maximum k-value of 0.23 BTU-in/hr-ft²-deg F at a mean temperature of 75°F.
- B. Flexible Elastomeric Pipe Insulation: ASTM C 534, Type I (-40°F to 200°F) (-40°C to 93°C), maximum k-value of 0.25 BTU-in/hr-ft²-deg F at a mean temperature of 75°F.

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- C. Jackets for Piping Insulation: Jacket assembly shall be ASTM C 1136, Type I with vapor retarder (0.02 perms). All service jackets shall have a polymer coated exterior facing, shall resist water staining and shall not support mold or mildew growth. All service jackets shall be Owens Corning ASJ Max with SSLII closure system, or equivalent.
 - 1. All fittings shall be provided with pre-molded insulation with equivalent thickness and composition of insulation applied to the adjoining piping. Encase pipe fittings insulation with one-piece premolded PVC fitting covers, fastened as per manufacturer's recommendations.
 - 2. Encase exterior piping insulation with 26 gauge embossed aluminum jacket with weather-proof construction.
- D. Bands, Wires and Cement: As recommended by insulation manufacturer for applications indicated.
- E. Adhesives, Sealer, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

2.3 DUCTWORK INSULATION MATERIALS (INDOOR)

- A. Flexible Fiberglass Ductwork Insulation: ASTM C 553, Type I, maximum k-value of 0.27 BTU-in/hr-ft²-deg F or minimum "out of package" R-value of 6.7 at a mean temperature of 75°F. For ductwork in ceiling space directly below roof, provide insulation with maximum k-value of 0.25 and minimum "out of package" R-value of 8.0 (1.5 LBS/FT³ density).
- B. Flexible Elastomeric Duct Wrap Insulation ASTM C 534, Type II, R-value of 8.0 at 2", (-40°C to 93°C).
- C. Ductwork Insulation Accessories: Provide bands, wires, tape, anchors, corner angles, and similar accessories as recommended by insulation manufacturer for applications indicated.
- D. Ductwork Insulation Compounds: Provide cements, adhesives, coatings, sealers, protective finishes and similar compounds as recommended by insulation manufacturer for applications indicated.

2.4 EQUIPMENT INSULATION MATERIALS

- A. Rigid Fiberglass Equipment Insulation: ASTM C 612-00, Type 1A (up to 450°F) (up to 232°C).
- B. Flexible Elastomeric Cellular Sheet Insulation: ASTM C 534, Type 2, R-value of 8.0 at 2", (-40°F to 200°F) (-40°C to 93°C).
- C. Jacketing Material for Equipment Insulation: Provide 8 ounce (227 g) canvas or pre-sized glass cloth jacketing material, not less than 7.8 ounces per square yard (263 g/m²), or

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- metal jacket at Installer's option, except as otherwise indicated.
- D. Equipment Insulation Compounds: Provide adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.
 - E. Equipment Insulation Accessories: Provide bands, wire, wire netting, tape corner angles, anchors, stud pins as recommended by insulation manufacturer for applications indicated.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.
- B. Only install mechanical insulation on systems while not in operation.

3.2 HVAC PIPING SYSTEM INSULATION

- A. Insulation Omitted: Omit insulation on hot piping within radiation enclosures and air conditioning condensate piping in mechanical rooms and/or on roofs.
- B. Refrigerant Piping (0 Degrees F - 200 Degrees F) (-18 Degrees C –93 Degrees C):
 - 1. Application Requirements: Insulate the following HVAC piping systems:
 - a. All refrigerant piping (gas and liquid).
 - 2. Insulate piping system(s) specified above with the following type and thickness of insulation:
 - a. Flexible Elastomeric: 1" (25 mm) thick.
- C. Cold Piping (40 Degrees F to ambient) (4 Degrees C to ambient):
 - 1. Application Requirements: Insulate the following cold HVAC piping systems:
 - a. HVAC chilled water supply and return piping.
 - b.
 - 2. Insulate each piping system specified above with the following type and thickness of insulation:
 - a. Flexible Elastomeric. 1" (25 mm) thick for pipe sizes up to and including 1" (25 mm), 1-1/2" (40 mm) thick for pipe sizes 1-1/14" (32 mm) and 1-1/2" (40 mm) and 2" (50 mm) thick for pipe sizes 2" (50 mm) and larger.

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D. Hot Piping (to 200 Degrees F) (to 93 Degrees C):

1. Application Requirements: Insulate the following hot HVAC system (water piping up to 200°F) (water piping up to 93°C).
 - a. HVAC hot water supply and return piping.
2. Insulate each piping system specified above with the following type and thickness of insulation:
 - a. Fiberglass: 1-1/2" (40 mm) thick for pipe sizes up to and including 1-1/4" (32 mm), 2" (50 mm) thick for pipe sizes 1-1/2" (40 mm) and larger.

E. Insulation of Piping Exposed to Weather: Protect outdoor insulation from weather by installing outdoor protective finish or jacketing as recommended by the manufacturer.

3.3 DUCTWORK SYSTEM INSULATION

- A. Insulation Omitted: Do not insulate fibrous glass ductwork, or lined ductwork located inside the building.
- B. Cold Ductwork:
 1. Application Requirements: Insulate the following cold ductwork:
 - a. Unconditioned outdoor air intake ductwork between air entrance and fan inlet or HVAC unit inlet.
 - b. HVAC supply air ductwork from air handling unit/fan discharge to diffuser or register, including all duct accessories (sound attenuators, etc.).
 - c. HVAC return ductwork located in ceiling directly adjacent to roof, including all duct accessories (sound attenuators, etc.).
 - d. HVAC plenums and unit housings not preinsulated at factory or lined.
 - e. Insulate neck and bell of supply diffusers.
 - f. External portions of air terminal (VAV, TRU's) heating coils.
 2. Insulate each ductwork system specified above with the following type and thickness of insulation:
 - a. Flexible Fiberglass: 2" (50 mm) thick with R-value of 6.7 (provide 2" thick with minimum R-value of 8.0 for supply ductwork located in ceiling space directly below roof), application limited to concealed locations.
 - b. Rigid Fiberglass: 2" (50 mm) thick, application limited to ductwork exposed to view, including mechanical rooms.
- C. Hot Ductwork (Above Ambient Temperature):

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1. Application Requirements: Insulate the following hot ductwork:
 - a. Hot supply and return ductwork between fan discharge, or heating unit discharge, and room diffuser/register; except omit insulation on return ductwork located in return air ceiling plenums.
 - b. Heating plenums and unit housings not pre-insulated at factory.
2. Insulate each ductwork system specified above with the following type and thickness of insulation:
 - a. Flexible Fiberglass: 2" (50 mm) thick.

3.4 EQUIPMENT INSULATION

- A. Cold Equipment (Below Ambient Temperature):
 1. Application Requirements: Insulate the following cold equipment:
 - a. Drip pans under chilled equipment
 2. Insulate each item of equipment specified above with the following type and thickness of insulation:
 - a. Flexible Elastomeric: 2" (50 mm) thick for surfaces above 35°F (2°C) and 3" (75 mm) thick for surfaces 35°F (2°C) and lower.
- B. Hot Equipment (Above Ambient Temperature):
 1. Application Requirements: Insulate the following hot equipment:
 - a. Hot water pumps
 2. Insulate each item of equipment specified above with the following type and thickness of insulation:
 - a. Rigid Fiberglass: 2" (50 mm) thick.

3.5 INSTALLATION OF PIPING INSULATION

- A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.
 1. Insulation materials shall not be applied until systems have been witnessed, documented, and submitted to meet pressure testing requirements indicated throughout these specifications.
- B. Install insulation on pipe systems subsequent to installation of heat tracing, testing, and acceptance of tests.

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- C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other.
- D. Clean and dry surfaces prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
- E. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage. Staples shall not be used.
- F. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Provide factory molded insulation or pre-fabricated fittings for all valves, fittings, unions, etc. Valve handles must be extended by the mechanical contractor to accommodate the insulation without reducing the thickness or integrity of the valve insulation.
- G. All water test ports shall be accessible from the insulation. In addition, water flow measuring stations require access from insulation to verify sizes and model.
- H. Extend piping insulation without interruption through pipe hangers, walls, floors and similar piping penetrations, except where otherwise indicated.
- I. Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply 3" (75 mm) wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3" (75 mm) wide vapor barrier tape or band. If using pipe hangers, follow manufacturer's instructions for installation.
- J. All exposed pipe insulation, including fittings, above 8'- 0" (2400 mm - 0 mm) of finished floor shall have 8 oz. (227 g) fire retardant canvas cover neatly cut and parted seams shall be sealed. Paint piping to match adjacent structure.
- K. All exposed pipe insulation, including fittings, within 8' - 0" (2400 mm - 0 mm) of finished floor or within a stairwell, shall be provided with aluminum or PVC protective covers. All edges shall be hemmed and all seams shall be concealed.
- L. All exterior piping shall be provided with an embossed aluminum jacket.
- M. For all insulated piping 2-1/2" (63 mm) and larger, provide insulated saddles as follows:
 1. For chilled water and heating water, provide the following:
 - a. Minimum 3.5 pcf, non-compressive, rigid, phenolic foam insulation. Fire and smoke rating shall be 25/50 or below per ASTM 84.
 - b. For cold applications below 75°F (24°C) a zero permeability abuse resistant vapor barrier shall be provided with matching butt strips. Apply a full coating of butyl joint sealant in addition to the butt strips for a completely sealed system.

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- c. The phenolic foam system shall have a K factor of 0.16 at a mean temperature for 75°F (24°C) and comply with ASTM Standard C1126.
- d. Provide visible inspection sticker at the bottom of each saddle.
- e. Pipe insulation saddles shall be Tru-Balance CoolDry Saddles as manufactured by Buckaroos, Inc. or equivalent.
- f. Armacell Armafix Pipe Hangers may be used for cold water piping with flexible elastomeric insulation.

3.6 INSTALLATION OF DUCTWORK INSULATION

- A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.
 - 1. Insulation materials shall not be applied until systems have been witnessed, documented, and submitted to meet pressure testing requirements indicated throughout these specifications.
 - 2. Install insulation materials with smooth and even surfaces.
 - 3. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
 - 4. Maintain integrity of vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage. Seal all joints with vapor barrier material.
 - 5. Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise indicated.
- B. Lined Ductwork: Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound lining has been specified.
- C. Corner Angles: Except for oven and hood exhaust duct insulation, install corner angles on external corners of insulation on ductwork in exposed finished spaces before covering with jacketing.
- D. All balancing damper handles shall be exposed and visible on externally insulated ductwork.

3.7 INSTALLATION OF EQUIPMENT INSULATION

- A. General: Install equipment thermal insulation products in accordance with manufacturer's written instructions, and in compliance with recognized industry practices to ensure that insulation serves intended purpose.
 - 1. Insulation materials shall not be applied until systems have been witnessed,

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documented, and submitted to meet pressure testing requirements indicated throughout these specifications.

2. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gaping joints and excessive voids resulting from poor workmanship.
 3. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.
 4. Do not apply insulation to equipment, breechings, or stacks while equipment is operating.
 5. Apply insulation using staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.
 6. Coat insulated surfaces with layer of insulating cement, troweled in workmanlike manner, leaving smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.
 7. If using fiberglass insulation, cover insulated surfaces with all-service jacketing neatly fitted and firmly secured. Lap seams at least 2" (50 mm). Apply over vapor barrier where applicable.
 8. Do not insulate boiler manholes, handholes, cleanouts, ASME stamp, and manufacturer's nameplate. Provide neatly beveled edge at interruptions of insulation.
 9. Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames and accessories.
- B. Equipment Exposed to Weather: Protect outdoor insulation from weather by installation of weather-barrier mastic protective finish, or jacketing, as recommended by manufacturer.

3.8 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division-23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

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3.9 SCHEDULING

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

3.10 EXISTING INSULATION REPAIR/REPLACEMENT

- A. Repair damaged sections of existing mechanical insulation, either previously damaged or damaged during this construction period. Insulation shall be as specified herein.
- B. Provide new insulation on existing mechanical piping where existing insulation has been removed due to damage, repair or abatement of existing hazardous materials.

3.11 PROTECTION AND REPLACEMENT

- A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
- B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION 230700

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SECTION 230900 – AUTOMATIC CONTROL SYSTEMS (ELECTRIC/ELECTRONIC)

PART 1 - GENERAL

1.1 SUMMARY

- A. Scope: The extent of automatic controls work is indicated on the drawings and schedules and by the requirements of this Section, and all other Division-23 sections. The work includes, but is not limited to the following:
1. The provision of a complete and operational control system, including all devices necessary to perform the functions herein described or indicated on the drawings.
 2. The provision of 120 and 208 volt line voltage and 5 and 24 volt low voltage wiring and conduit types shall be installed in accordance with Division-26 of these specifications.
 3. The ATC contractor shall furnish and install all electrical wiring and conduit from power source, including termination, to all required ATC related power connections including, but not limited to, DDC controllers (provide low voltage controllers for air terminal units including transformers and disconnect switches as required), sensors, valve and damper actuators (including smoke dampers), air flow monitors, ATC panels, etc. The ATC contractor shall obtain a separate electrical permit as required by the local authority. The ATC contractor shall be wholly responsible for all power requirements necessary for a complete installation from the power source to all ATC related connections. The intended power source shall be as indicated on the electrical plans. All electrical work shall be installed in accordance with Division-26 of these specifications.
 4. The ATC contractor shall interface with fire alarm devices as required to accomplish equipment shutdown, alarms, etc. indicated in sequences.
 5. The ATC contractor shall coordinate and verify that all controllers, devices, and accessories are provided as required to accomplish all control functions and sequences indicated in the contract documents. Where control related devices are not provided by an equipment manufacturer, it shall be the responsibility of the ATC contractor to provide the control devices required to accomplish the functions and sequences indicated.
 6. All drilling, cutting and patching associated with the installation of control systems.
- B. Types: Provide automatic control systems of the following types:
1. Direct Digital Control (DDC) with electric actuation of valve and damper actuators.
 - a. The controls system shall utilize a single software platform (Use of a secondary system for controller configuration shall be unacceptable)

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- b. Tridium Niagara N4 Framework (open-protocol and open NIC ONLY) specific controllers only. This shall include supervisory and unitary controllers.
 - c. All controllers, both supervisory and unitary (unit controllers) must be programmable. No configurable controllers will be accepted by CACPS.
2. The automatic temperature control system shall include remote interface and web access capability. All building management system control features including, but not limited to, points, alarms, scheduling, graphics, trending, etc. shall be available for control and monitoring through web access as well as remote interface with FIN Stack front end system at the Facilities Command Center.

1.2 QUALITY ASSURANCE

- A. Systems Engineering: The systems engineering phase shall include the selection and integration of components into a complete system which will meet the performance and prescriptive requirements of the Contract, together with drawings, specifications, descriptions of operation, diagrams and other materials listed under "Submittals" paragraph of this Section.
- B. Testing and Adjusting During and After Installation:
 - 1. The testing and adjusting includes the submission of a test plan which shall describe in detail the method by which each component, subsystem, and system will be tested, calibrated, adjusted, and retested after installation in accordance with the specified sequences of operation and other characteristics of the control system. A report on test results, including set points and operating ranges of all components shall be submitted.
 - 2. The testing specified in this paragraph shall not replace the testing specified in "Commissioning Tests and Verification" article of this Section.
- C. Commissioning Testing and Verifications: The final phase of the quality assurance program of the project is the commissioning testing and verifications. This phase is to assure that the project is fully completed and that the systems are performing in accordance to specifications from end to end of the control systems. Demonstrations of the automatic control systems to the commissioning team in accordance to the requirements specified in Part 3 of this Section are required. A report on test results, including set points and operating ranges of all components, shall be submitted.
- D. Testing: The testing phase of quality assurance includes the submission of a test plan which shall describe in detail the method by which each component, subsystem, and system will be tested, calibrated and retested after installation to perform in accordance with the specified sequences of operation and other characteristics of the control system.
- E. Reporting and Demonstration: This phase shall include the submission of a written report describing the "actions taken during the testing" phase, and including the set points and operating ranges of all equipment and a demonstration that the system performs in accordance with contract requirements.

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- F. Operating Instructions and Training: This phase of quality assurance includes the training of operating personnel utilizing written operating instructions prepared and approved under the "Submittals" paragraph of this Section, and the mounting of laminated control diagrams where directed.
- G. Maintenance Manuals: This phase includes the submission of four hard bound copies of all manufacturers' cuts, maintenance and operating instructions, test reports and demonstration material, copies of control diagrams, and copies of the manufacturers' certifications.

1.3 SUBMITTALS

- A. Shop Drawings: For each system to be controlled, prepare a drawing which includes a system flow diagram, control diagram, sequence of operation and schedule of components. Control diagrams shall be complete with end-to-end connections of piping and wiring from component terminal.
- B. Manufacturer's Data: For each manufactured device or subsystem submit manufacturers' specifications and printed photograph of the proposed device or subsystem. Include engineering descriptions, principle of operation and application, and proposed model, style or size clearly indicated.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. The automatic temperature controls shall be furnished, installed, commissioned and warranted by one of the following acceptable providers:
 1. Electrical Automation Services, Inc. – Pasadena, MD
 2. Any other providers must be approved by CCPS prior to contract award and must meet the following minimum qualifications:
 - a. ATC contractor shall be a licensed provider of FIN Stack and must have a minimum of 5 years' experience working with FIN Stack.
 - b. ATC contractor shall have at least 50 employees with construction and service. Employees must work for the controls division.
 - c. ATC contractor must self-perform all ATC work including but not limited to electrical installation.
 - d. ATC contractor must have a service department with 24/7 response.
 - e. ATC contractor shall be located within 50 miles of the project site.

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2.2 GENERAL REQUIREMENTS

- A. The complete system shall be warranted for a period of two (2) years from the date of substantial completion. A comprehensive test, evaluation, training and follow-up program shall be specified by the engineer to ensure that the system operates as designed over the life of the system during warranty period and beyond.
- B. All software updates available for the ATC system during the warranty period shall be installed and tested to ensure proper operation at no extra cost to CCPS.
- C. The ATC system in all schools shall be open protocol BACNET connecting back to the existing FIN Stack front end at the Facilities Command Center.
- D. Sole sourced DDC Controllers with proprietary software and programming requirements shall not be approved by CCPS for installation. The ATC contractor shall not order any controllers without prior approval of the owner.
- E. Programming for **all** devices (supervisory and unitary) shall use Niagara software only; “wizards” and plug-ins are **NOT** acceptable. **All** programming language and graphics shall be the same software package and shall remain the property of CCPS. The use of more than one software package shall be considered non responsive and will not be accepted.
- F. All software and hardware shall be licensed to CCPS.
- G. All software, hardware, and training must be able to be purchased from several vendors. Branch only purchases will not be accepted.
- H. CCPS shall have the ability to be self-sufficient with regards to installation and programming of all software and hardware.
- I. Each DDC controller shall communicate over a BACnet communications bus installed between the controllers by the ATC subcontractor. A communications master control panel shall be provided by the ATC subcontractor. This panel shall:
 - 1. Provide CCPS personnel with a convenient location to obtain system information using a laptop or a hand-held terminal. The hand-held terminal shall be available from more than one manufacturer as a standard product. School staff shall have access to the system to view space temperatures only.
 - 2. Collect ATC information and transmit it to the main ATC panel.
 - 3. Receive energy management directions from the main ATC panel.
- J. Within 10 working days of Contract Award a meeting shall be scheduled with CCPS, the General Contractor, the Controls Contractor, the Equipment Manufacturer, and the Commissioning Agent where applicable. The purpose of the meeting will be to develop the sequences, points lists, and interfaces necessary to reduce the number of issues.

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- K. All controllers, sensors, and switches shall be hard-wired. All connections between the main ATC panel and sub-panels/controllers shall be hard-wired. Wiring shall be installed in accordance with Building and Electrical codes as well as any other applicable codes.
- L. All equipment shall have a RIB switch relay override for service and troubleshooting.
- M. All equipment shall be controlled by a stand-alone DDC controller. These controllers shall be provided and field installed by the ATC contractor. The ATC system shall only enable these pieces of equipment which are expected to run 'stand-alone'. Factory controllers will not be acceptable.
- N. The data transmitted from the ATC system to the Command Center shall include the following, as a minimum; in addition to information included on ATC drawings:
 - 1. Equipment Information:
 - a. Start/Stop signals for all equipment
 - c. Adjustable reset schedules
 - 2. General Information:
 - a. HWS Temperature
 - b. HWR Temperature
 - c. CWS Temperature
 - d. CWR Temperature
 - f. Outside Air Temperature
 - i. Alarm Data
 - 3. Zone Information:
 - a. All true Fan Status (On/Off/Speed):
 - Read differential pressure for water
 - Read status and safeties for air
 - b. Zone Temperature as measured by Zone Sensor
 - c. Override Status
 - d. Alarm Data (i.e. readings outside of normal system parameters)
 - Temperature $\pm 10^\circ$ from set point for 1/2 hour

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- e. CO₂ Level of Zones (where indicated on drawings)
- f. Discharge and Return Air Temperature for Zones with constant volume and variable volume Air Handling Units.
- g. Equipment Status (Default/Open/On/Off)

P. Schedules:

- 1. Provide separate area scheduling capabilities for:
 - a. Administration
 - e. Cafeteria
 - g. Classrooms: Zones shall be determined with AACPS
 - i. All spaces associated with the performing arts addition
 - j.

Q. Graphics:

- 1. All proposed graphics shall be provided to CCPS as submittals for review and approval prior to installation.
- 2. The home screen for each school shall include links to the Mechanical and Controls drawings and Balancing Reports.

2.3 SYSTEMS INTEGRATION

- A. Control Loop Characteristics: Carefully evaluate the characteristics of each control loop, the time constants, equipment characteristics, control accuracy, and reliability and provide a system which will operate smoothly, without hunting, and within the accuracies specified.
- B. System Components: Select components including sensors, transmitters, controllers, control devices, actuators, and instrumentation considering such factors as hysteresis, relaxation time, span, limits, and response time.

2.4 CONTROLLERS

- A. General: Provide electric or electronic controllers for each local control loop.
 - 1. Provide controllers with local adjustable setpoint, adjustable proportional band for analog controllers or adjustable differential for two position controllers.

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2. Provide adjustable secondary input authority for dual input controllers with remote setpoint adjustment.
 3. Provide integral or test connections for measuring input and output signal.
- B. Electric/Electronic System Characteristics: Provide a system of control which shall have all of the following system characteristics. Systems which do not conform to all of the following requirements will not be acceptable.
1. The system shall consist of multiple, field adjustable controllers. The controller, power supplies, input/output and other components specified, including metal cabinet will be referred to as a "Field Panel."
 2. The field panel shall be capable of performing its assigned local loop control and other functions as a standalone unit. It shall perform all specified local loop control functions without interaction to other field panels, except for shared functions such as central time programs, heating-cooling changeover, etc.
 3. The field panel shall utilize control algorithms that permit proportional, integral, and derivative control as required. Control algorithms shall permit one, two or three mode control as specified or indicated on the drawings.
 4. Each field panel shall be capable of handling multiple control loops, with one or more controllers.
 5. The system shall utilize industry standard sensors.
 6. The field panel shall provide both analog and binary output control. Analog outputs shall be compatible with industry standard transducers. Provide a modulating analog output control signal. Binary output control commands shall be implemented through interposing control relays.
 7. Field panels shall be of modular construction. The system shall utilize interchangeable components. The modular construction of the system shall permit quick repair, ease of expansion, and the use of standard controls.
 8. Each field panel with sensors and controlled devices shall be capable of automatic, unattended restart in the event of electrical power failure. In the event of electrical power failure all controlled devices shall move to their predetermined "normal" positions. By normal, it is meant that spring-close valves shall close, spring-open devices shall open, spring return devices will return and magnetically held devices will move to the position dictated by the force of gravity. Upon the restoration of electrical power, the field panel shall automatically restart and provide control to its connected systems after power failures of up to 72 hours.
 9. The field panel operating system shall reside in nonvolatile memory.
 10. Site specific application data, setpoints and operator entered data shall be stored in volatile memory.
 11. Nonvolatile memory shall include PROM, EPROM, EAROM, ROM and RAM.

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12. The preceding terms describe a class of solid state semi-conductor memories manufactured with LSI (large-scale-integration) techniques. These terms are expanded as follows:
 - a. PROM - Programmable Read Only Memory
 - b. EPROM - Erasable PROM
 - c. EEPROM - Electrically Alterable ROM
 - d. ROM - Read Only Memory
 - e. RAM - Random Access Memory
- C. Field Panels: Provide field panels as follows.
 1. Each field panel shall consist of a controller, power supplies, input/output modules, and other components specified.
 2. Provide field panels where indicated. Provide additional controllers, if required, to support the control loops specified, the sequence of operations, number of monitoring points or other criteria to permit the field panel capacity to meet the specified functional requirements of the project.
 3. Each field panel shall be capable of operation as a completely independent unit.
 4. Each field panel or controller shall include its own operator's keypad or other means of adjustment on site by the operator.
 5. Each field panel shall receive signals from industry standard sensors and input devices. Each panel shall have the capability to monitor the following types of inputs:
 - a. Analog inputs: 4 to 20 mA and 0 to 10 V DC.
 - b. Binary inputs: Dry contact closure and pulse accumulator.
 - c. Provide transducers and/or signal conditioning to adapt other sensor types.
 - d. Field panels that permit the direct connection of resistance type sensors will be acceptable if the system accuracy, data resolution, value accuracy and sensor interchangeability, comply with all other requirements of the specification.
 6. The field panel shall directly control actuators and control devices. Each field panel shall be able to provide the following control outputs:
 - a. Binary outputs: Contact closure
 - b. Analog outputs: 4 to 20 mA, 0 to 10 V DC and 0 to 135 OHM.

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- c. Systems that do not provide direct analog outputs will be acceptable providing that they generate the specified output signal through transducers.
 - 7. Each field panel shall perform control functions and other routines, specified under Sequences of Operation.
 - 8. Each field panel shall accept binary inputs, on-off, open-close, or other two state data. Provide isolation and protection against input voltage up to 180 VAC peak.
 - 9. Each field panel shall provide Binary Output by contact closures for momentary and maintained operation of field devices. Provide electromagnetic interference suppression on all output lines to limit transients to non-damaging levels. Provide isolation and protection against voltage up to 180 VAC peak. Provide contacts rated for 2 A at 24 VAC.
 - 10. Each field panel shall be enclosed in a metal cabinet. The cabinet shall be constructed of 16 US gauge sheet steel, Provide sufficient access for wire and conduit to enter the cabinet. The cabinet shall have a hinge door and a pin tumbler lock. All field panel locks for the project shall be keyed alike. The cabinet shall be shipped to the project for installation without electronics. The electronics shall be added at the time of wire termination and system commissioning. All control wiring and system communications shall be electrically terminated inside the field panel.
 - 11. Provide a 15A duplex receptacle inside or immediately adjacent to the field panel. The receptacle shall be energized when power is disconnected from the field panel.
 - 12. Ground the field panel and power supply with a minimum No. 12 THHN unbroken ground wire to the building earth ground system. There shall be a maximum of 5 ohms measured between the ground at the field panel and the building ground system.
 - 13. Provide a master electrical power disconnect switch inside the field panel to disconnect all external power to the cabinet for maintenance and repair. The disconnect switch shall not affect the duplex receptacle hereinbefore specified.
 - 14. Provide screw type terminal strips in the field panel for the termination of all field wiring. Lay out terminal strips in a neat and orderly fashion and label each termination. All wiring entering the panel shall be routed through the panel wireways in a neat and workmanlike manner, properly tied or laced and terminated.
 - 15. Provide conduit and wire to connect the field panel to the nearest adequate source of emergency electric power.
- D. Wire/Cable Labeling: Label wire and cable as follows.
- 1. Label each cable and each conductor within 6 inches (150 mm) of the termination point. Cable and wire identification shall match the wiring identification shown on the installation and record drawings.

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2. Wire identification labels shall be securely affixed to the wire and shall be of the preprinted type providing a durable vinyl or plastic covering over the printed lettering.
 3. Wire identification through color coding, embossed label tape, paper tags attached with string and handwritten labeling will not be acceptable.
- E. Transient Protection: Provide transient protection as required by the manufacturer.
- F. System Accuracy: Provide system accuracy in accordance with the following.
1. Each local system shall maintain end-to-end accuracy for one year from sensor to controlled device for the applications specified.
 2. Space temperature with a range of 50°F to 85°F (10°C to 29°C) plus or minus 0.75°F (.4°C) for conditioned space; 30°F to 130°F (-1°C to 54°C) plus or minus 1.0°F (.6°C) for unconditioned space.
 3. Duct temperature with a range of 40°F to 140°F (4°C to 60°C) plus or minus 1.0°F (.6°C).
 4. Outside air (OA) temperature with a range of minus 30°F to plus 130°F (minus -1°C to plus 54°C) plus or minus 2.0°F; with a subrange of plus 30°F to plus 100°F (plus -1°C to plus 38°C) plus or minus 1.0°F (.6°C).
 5. Water temperature with a range of 33°F to 100°F (1°C to 38°C) plus or minus 0.75°F (.4°C); the range of 100°F to 250°F (38°C to 121°C) plus or minus 2.0°F (1.2°C); and water temperatures for the purpose of performing BTU calculations using differential temperatures to plus or minus 0.5°F (.3°C) using matched sensors.
 6. High temperature water with a range of 0°F to 500°F (-18°C to 260°C) plus or minus 3.0°F (1.6°C).
 7. Pressure with a range for the specific application plus or minus 2.0 percent of range.
 8. Flow with a range for the specific application plus or minus 3.0 percent of range, and flows for the purpose of BTU calculations to plus or minus 2.0 percent of range.
- G. Accuracy and Stability: Equipment shall be selected for the appropriate range of the application. Equipment selected with ranges in excess of the application will be replaced at the Contractor's expense.

2.5 SENSORS

- A. General: Provide analog sensors for temperature controllers. Provide sensors with an output signal that varies continuously with the sensed temperature, within a specified range, of the thermistor or resistance type.

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- B. Manufacturer: Temperature sensors shall be made by one manufacturer.
- C. Space Sensors: Provide space or room sensors with base plates thru-bolted into masonry or wall studs, brushed cast aluminum or 16 gauge (1.6 mm) ground and polished Type 316 stainless steel covers.
- D. Insertion Type: Stem or extended surface sensitive type with screw mounting plate and galvanized sheet steel insulation mounting box.
- E. Immersion Type: Stem or tip sensitive type with threaded immersion well base.
- F. Sensing Elements: Hermetically seal, except for bimetal type for room thermostats. Stem, tip or extended element shall be Type 304 stainless steel or annealed copper.
- G. Casing: Casing shall be constructed of watertight, vibration-proof, heat resistant high strength phenolic or 316 stainless steel.
- H. Sensor Wells: Provide 304 stainless steel, bronze, copper or monel machined wells, compatible with the immersion medium, and heat sensitive transfer material or liquid between sensor and well surface.

2.6 ELECTRONIC ANALOG SENSORS

- A. Range: Sensors shall operate within the range of minus 30°F to plus 220°F (minus -34°C to plus 104°C) for heating, ventilating and air conditioning (HVAC) systems.
- B. High Temperature Sensors: For high temperature water applications provide sensors with a range of 0°F to 500°F (-18°C to 260°C).
- C. Accuracy: Provide electronic analog sensors with an accuracy of plus or minus 0.25°F (.14°C).
- D. Time Constant Response: Provide sensors with a time constant response to achieve 60 percent of a step temperature change in six (6) seconds in air or water flowing at 3 feet per second (.9 m/s).
- E. Interchangeability: Sensors of the same type shall be interchangeable without calibration.

2.7 PRESSURE SENSORS

- A. Overpressure Protection: Provide pressure sensors impervious to instantaneous pressure changes of 150 percent of working pressure but not less than plus or minus 50 psig (340 kPa).
- B. Adjustment: Provide sensors with external adjustable span, adjustable zero and pulsation suppression.

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- C. Finished Spaces: Conceal pressure sensors in recessed stainless steel housing with removable perforated brushed stainless steel cover.
- D. Sensor Characteristics: Provide pressure sensors with the following characteristics:
 1. Ambient Temperature: 40°F to 140°F (4°C to 60°C).
 2. Isolation Valves: Provide pressure sensors with stainless steel needle isolation valves between each sensor and sensor pressure source. Provide differential pressure sensors with 3-valve manifold for isolation and nulling.
 3. Provide switching type sensors with platinum alloy, silver alloy or gold plated wiping contacts rated for the application, voltage and power levels.
 4. Provide valved calibration taps adjacent to each pressure sensor for calibration.

2.8 STATIC PRESSURE ANALOG SENSORS

- A. Types: Provide diaphragm sensors with solid state pre-amplifier electronic systems.
- B. Characteristics: Provide analog sensors with the following characteristics:
 1. Sensor span shall be not less than 150 percent and not more than 300 percent of the working pressure.
 2. Accuracy shall be 0.5 percent of calibrated span including combined effects of linearity, hysteresis and repeatability.

2.9 DIFFERENTIAL PRESSURE ANALOG SENSORS

- A. Types: Provide differential pressure analog sensors of the solid state pre-amplifier types for electronic systems.
- B. Characteristics: Provide sensors with the following characteristics:
 1. Sensor span not less than 150 percent nor more than 300 percent of the working differential pressure.
 2. Accuracy of 0.5 percent of calibrated span, including combined effects of linearity, hysteresis and repeatability.
 3. Pressure sensor shall withstand overpressure of not less than 200 percent working pressure and full vacuum underpressure without damage, changes in sensor accuracy or deformation.

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2.10 DEW POINT AND RELATIVE HUMIDITY SENSORS

- A. Dew Point Sensors: Provide analog salt-phase transition or dual cooled mirror type sensors with an accuracy of plus or minus 3°F (1.6°C) dew point over the range of 10°F to 100°F (-12°C to 38°C) dew point.
- B. Relative Humidity Sensors: Provide analog precision resistance or hydro-mechanical gauge type relative humidity sensors, with an accuracy of plus or minus 2 percent of relative humidity over a range of 10 to 90 percent relative humidity.
- C. Shields: Provide 316 stainless steel weatherhoods and shields to protect outdoor sensors from sunlight, snow, ice, wind and rain and provide fan powered aspirator complete with wiring if recommended by the manufacturer.
- D. Indoor Covers: Sensors located in public spaces shall have brushed 16 gauge (1.6 mm) 316 stainless steel covers or recessed aspirating boxes with Allen head screw mounting plate.

2.11 THERMOSTATS/TEMPERATURE SENSORS

- A. Types: Provide electronic thermostats/temperature sensors which operate in an analog proportional or binary two-position mode as required by the sequence of operation.
- B. Mounting: Mount in non-public spaces except room temperature sensors.
- C. Room Temperature Sensors: Provide electric analog temperature sensors for all rooms with the following characteristics:
 - 1. Sensor shall be of the bulb or capillary type which shall actuate a 135 ohm 3-wire potentiometer for 0-10 VDC, or 4-20 milliamp proportioning control action of balanced bridge motor actuators.
 - 2. Sensor shall have adjustable setpoint range of not less than 80°F (27°C) throughout the range of 0°F to plus 250°F (-18°C to plus 121°C).
 - 3. Adjustable proportional band ranges from 3°F to 25°F (-16°C to -4°C) and capillary length of not less than 5 feet (1500 mm) shall be provided.
- D. Electric Two Position Duct and Immersion Thermostats: Provide thermostats with bimetal or bulb and capillary type sensor actuating one or more switching contacts.
 - 1. Contact shall be rated for the imposed load or shall be a pilot duty type and provided with a control relay.
 - 2. Thermostats shall have adjustable setpoint throughout the range 0°F to plus 250°F (-18°C to plus 124°C).
 - 3. Differential shall be adjustable from 3°F to 10°F (-16°C to -12°C) for each contact for refrigeration, boiler and industrial applications.

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4. Fixed differential thermostats with differentials of 3 may be provided for On-Off control of unit heaters, ventilating fans and similar applications.
 5. Provide capillary tubes in the 5 to 20 feet (1500 to 6000 mm) lengths to suit applications.
- E. Freeze Protection Thermostats: Electric freeze protection thermostats shall be provided with capillary elements, and special purpose insertion elements not less than 20 feet (6000 mm) in length for the face of coils up to 80 square feet (7.4 m^2). Freeze protection thermostats shall have the following characteristics:
1. A freezing condition at any one foot length increment anywhere along the sensing element shall activate the thermostatic switch.
 2. Switch shall require manual reset.
- F. Weather Shields: Provide weather shields and outside air sensing elements with the following characteristics:
1. Mount elements and shields on the north face of the building or location out of direct sunlight.
 2. Construct shields of 16 gauge (1.6 mm) 316 stainless steel with flanges bolted to a backplate with not less than four 1/4-inch (6 mm) diameter stainless steel bolts. Mount backplate to the building structure with expansion bolts.
 3. Construct shields to inhibit solar effects. Construct shields in a rectangular box configuration with ventilating raintight louvers to preclude the entrance of snow, ice and rain. Design for crossflow and vertical air circulation.
 4. Mount shields accessible for maintenance.
 5. Seal wall penetration watertight.

2.12 PRESSURE CONTROLLERS

- A. Types: Provide electric electronic pressure controllers of the analog or two- position type as required by the sequence of operation.
- B. Analog Controllers: Provide controllers with proportional action plus integral and derivative control modes.
1. Provide sensing elements of the differential type measuring controlled medium and standard reference pressures.
 2. Air static pressure controllers shall have slack diaphragms with standard ranges 0 to 6 inches water column (0 to 1500 Pa) and an adjustable proportional band range of 0.02 to 0.5 inches water column (5 to 125 Pa).
 3. Sensing elements for duct applications shall be damped to preclude pulsation.

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4. Water differential pressure controllers shall have a minimum range of 0 to 50 psig (0 to 345 kPa) or 0 to 250 psig (0 to 1725 kPa) as required by the application with adjustable proportional band of one to 25 psig (170 kPa). Sensing elements shall be diaphragm type with 3-valve manifold. Provide siphons and pressure snubbers.

2.13 ELECTRIC PRESSURE SWITCHES

- A. Type: Provide bourdon tube or diaphragm type electric pressure switches with tamperproof adjustable set point and differential settings. Design switches for 200 percent overpressure and full vacuum underpressure without damage or accuracy impairment.

2.14 DAMPERS

- A. Standards: Provide opposed blade and parallel blade factory fabricated dampers of extruded aluminum, galvanized steel or stainless steel with metallic anti-friction non-ferrous bearing in accordance with Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) standards.
- B. Types: Use parallel blade dampers in mixing chambers and plenums. Use opposed blade dampers for volume control, face and bypass dampers, smoke dampers, fan discharge, and variable air volume control.
- C. Pressure Rating: For fan systems less than 10-inch water gauge (2490 Pa) static pressure, design and construct dampers to withstand a pressure of 150 pounds per square foot (7.1 kPa) without damage, leakage, flexure, or distortion.
- D. Leakage: Maximum air leakage rate for all dampers shall not exceed 10 cubic feet of air per minute per square foot (50 L/s/m²) at atmospheric pressure when closed against a 4-inch water gauge (1000 Pa) static pressure.
- E. Operators: Damper operators shall have sufficient power to open and close the dampers and limit the leakage to the specified rate. Power wiring shall be extended to operator by this contractor.
- F. Shafts and Bearings: Provide cadmium plated steel shafts in permanently lubricated bronze sleeve bearings or permanently lubricated ball bearings.
- G. Blade Sizes: Reinforced or ribbed blades shall not exceed 8 inches (200 mm) in width nor 48 inches (1200 mm) in length.
 1. Flat or unreinforced blades will not be acceptable.
 2. Damper sections exceeding 4 feet (1200 mm) in width or 4 feet (1200 mm) in height shall be constructed with multiple frames and linkages.
- H. Frames: Construct frames of factory welded galvanized steel hot dipped after construction or bolted extruded aluminum frames.

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1. Dampers larger than 8 square feet (.7 m²) in area shall have corner bracing gussets at each corner welded to the damper frame.
- I. Linkages: Provide linkages to uniformly transmit damper operating forces to each damper blade.
 1. Construct linkages of galvanized or cadmium plated steel or stainless steel.
 2. Bearings and joints shall be ball and socket or sleeve bearings of brass, bronze or stainless steel, with plated bolts and locking nuts.
- J. Seals: Provide mechanically attached elastomer or neoprene blade tip seal along the full length of each blade edge and flexible stainless steel seals along damper blade ends where the blades abut the frame. Adhesives or staples will not be acceptable.
- K. Damper Mounting: Mount dampers to casings and ductwork in conformance with SMACNA standards. Provide welded or bolted galvanized steel structural supports for dampers larger than 20 square feet (1.9 m²). Through bolt damper frames to structural supports.

2.15 AUTOMATIC VALVES

- A. Standards: For chilled water and low temperature hot water provide valves conforming to ANSI B16.15, "Cast Bronze Threaded Fittings," Class 125 copper bearing steel, bronze, or ANSI B16.1, "Cast Iron Pipe Flanges and Flanged Fittings," Class 125 cast iron. For high temperature water and water above 100 pounds per square inch (690 kPa) provide valves conforming to ANSI B16.5, "Pipe Flanges and Flanged Fittings," cast steel or stainless steel. Select valve pressure class minimum 150 percent of maximum working pressure.
- B. End Connections: Provide valves with end connections as follows:
 1. For chilled water and low temperature hot water provide valves with flanged connections on sizes 2-1/2 inches (65 mm) and larger and threaded connections on valves 2 inches (50 mm) and smaller.
- C. Small Water Valves (1" and Smaller): For valves controlling low pressure and low temperature chilled or hot water sizes one inch and smaller, bodies shall be bronze, cast iron or stainless steel with screwed, union or flare connections.
- D. Valve Trim: Provide valve trim as follows:
 1. Stems shall be 316 stainless steel.
 2. Disk and stuffing boxes may be bronze or 316 stainless steel.
 3. For all valves 1-1/2-inch (40 mm) and larger, stems, disks, and seats shall be 316 stainless steel.

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4. All non-metallic parts of hot water valves shall be designed for minimum 250°F (121°C) or 100°F (38°C) above system design temperature.
 5. Leakage: Control valves shall provide tight shut off in the closed position at 150 percent of maximum working pressure.
- E. Valve Characteristics: Select valves to provide equal percentage control of water. Water shall have tapered plugs.
1. Butterfly valves that do not have "equal flow characteristics" will not be acceptable for modulating control.
 2. For two-position, water application action, butterfly valves may be used, provided the differential pressure across the valve does not exceed 25 pounds per square inch (170 kPa).
- F. Sizing: Provide valves of sizes indicated, or as herein specified.
1. Size water valves with a maximum differential pressure not greater 10 feet (480 Pa) or 1/2 the loss through the controlled apparatus, whichever is greater.
- G. Actuators: Provide actuators, sized by the manufacturer, of sufficient size and power to operate the valve under all conditions and to close the valve tight against maximum differential pressure.
1. Provide pilots for sequence operations, and cases where valve spring ranges have been increased to close off against system pressure.
 2. Comply with requirements of "Actuators" paragraph of this Section.

2.16 ELECTRIC ACTUATORS

- A. General: Provide electric motor driven actuators (operators) arranged "Fail Safe" in the event of power failure. Unless indicated otherwise, the fail position of each valve shall be the "last position" or "current position" at the time of failure. Design operators to be quiet in operation and function within a range 85 to 100 percent input power potential.
- B. Electric Actuators: Provide hydraulic or gear type electric actuators.
1. When operated at rated voltage each actuator shall deliver the torque required for continuous uniform movement of the control device from limit to limit.
 2. Provide an end switch to limit travel and design the actuator to continuously stroke without damage.
 3. Operators shall function properly within a range of 85 to 120 percent of line voltage. For actuators with input power greater than 100 watts, gears shall be ground steel, oil immersed, shaft shall be hardened steel running in bronze, copper alloy or ball bearing and operator and gear trains shall be totally enclosed in dustproof cast iron, cast steel or cast aluminum housing.

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4. Actuators with input power less than 100 watts may use fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings and pressed steel enclosures.
 5. Two position actuators shall be of the single direction, spring return or reversing type.
 6. Proportioning operators shall be capable of stopping at all points in the cycle and starting in either direction from any point.
 7. Reversing and proportioning operators shall have limit switches to limit travel in either direction.
 8. For actuators with greater than 400 watts input, provide totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- C. Damper Operator Mounting: Mount damper operators where accessible for maintenance.
1. If located outside the duct or casing, mount operators on a 14 gauge (2.0 mm) reinforced support plate arranged to allow insulation between the support plate and the face of the duct or casing.
 2. Brace damper operators rigid to show no deflection or movement over the full range of the damper stroke.

2.17 CONTROL PANELS AND CABINETS

- A. Local Panels and Cabinets: Provide local control cabinets for each air handling unit, automatically controlled equipment such as pumps, fans, heaters and convertors, or groups of such equipment in a single mechanical equipment room.
- B. Standards: Construct panels in conformance with UL 50, "Cabinets and Boxes," or similar approved construction, with backbox, full-sized piano hinged face, stainless steel lockable latch, and secure to the building construction.
1. Internally mount all controllers, relays, terminal boards, and miscellaneous control devices, on a removable panel.
 2. Flush mount in the door all indicators, selector switches, remote setpoint adjusters, and pilot lights.
 3. Cabinet internals may be factory or field wired and piped. Wire shall be neat, braced, and strapped flat to present a neat appearance and to easily trace wiring and piping from one device to another.
 4. Floor mounted panels shall be bolted to 1-1/2-inch by 1-1/2-inch (40 mm by 40 mm) structural support channel, bolted to the floor and braced at the top.

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2.18 SYSTEM DIAGRAMS

- A. Mounting: Mount control diagrams adjacent to each local control panel on a furniture steel extension either bolted to wall or to an extension of the control cabinet structural support.
 - 1. Control diagrams shall include system one-line diagram, system control diagram, sequence of operations, and schedule of control devices.
 - 2. Diagrams shall be hermetically sealed in laminated 16 gauge (1.6 mm) plastic.
 - 3. Diagrams shall be permanent, black on white background, not subject to fading when subjected to artificial or natural light. Diazo prints are not acceptable.
 - 4. Diagrams shall represent the current, "as-built" status of the control system, after acceptance by the representative of the Owner.
 - 5. Obsolete, out of date, or field modified diagrams shall be removed, and new current diagrams furnished.
 - 6. Diagrams and devices on local control panels shall be identified with engraved phenolic nameplates, white on black, minimum 1/4-inch (6 mm) high block capital lettering, screwed or bolted to panel or mounting plate face. Adhesive attachments are not acceptable.

2.19 WIRING

- A. General: Provide a complete system of electric wiring for temperature control apparatus including control power transformers and wiring to the transformer primary.
- B. All wiring above acoustical tile lay-in ceilings may be open cable with J-hooks. In all other areas (i.e. exposed area, above gyp ceilings, etc.) wiring shall be installed in conduit. Refer to Division-26 section, "Raceways." MC cable is prohibited in all locations.
- C. Wiring: Wire for low voltage AC shall be minimum 300 volt insulated copper No. 18 AWG or larger conforming to NFPA 70, Type MTW, THHN or TFFN, installed in accordance with Division-26 of these specifications.
 - 1. For low voltage DC and an electronic circuit carrying less than 0.5 amperes, cables of two or more conductors not smaller than No. 18 AWG solid copper or No. 18 AWG solid copper if not shielded may be used in lieu of individual wires.
 - 2. Cables carrying analog signals shall be shielded, if required by the manufacturer.
 - 3. Cables shall be terminated in solder or screw type terminal strips.
 - 4. Cables shall not be tapped at any intermediate points.
 - 5. All wire shall be color coded or numbered for identification. Identify as indicated on shop drawings and "as-built" drawings.

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6. Wire terminating in screw type terminal strips shall have pressure connectors conforming to UL 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors," or UL 486B, "Wire Connectors for Use with Aluminum Conductors."
 7. Wire terminations without connectors or traveling pressure pads will not be accepted.
- D. The contractor shall in no case combine control wiring (line or low voltage) with power wiring in the same conduit.

2.20 ACCESSORIES

- A. Provide a PC based operator's workstation within the building at a location determined by the owner, including a flat screen monitor (minimum 21") and a color laser printer. Provide color graphics of all systems to be controlled, monitored and alarmed by the EMCS. Computer hardware and software shall be compatible with the most current version of the ATC vendor's software and graphics packages.
- B. Provide a portable operating terminal for connection to the main DDC control panel. In addition, main panel shall be provided with modem connection.

2.22 FLOW SENSORS

- A. General: Provide sensors for measuring flow in piping and ductwork that are compatible with static pressure and differential pressure analog of the electronic controllers served.
- B. Turndown: Provide sensors with an output characteristic which gives a continuous mathematical function over the full range of flow from maximum to minimum required.
- C. See specifications, this section, for required air and/or water flow monitor measurement characteristics.
- D. Provide all necessary power and control wiring as required for complete and operational flow measurement systems interlocked with the building EMCS.

2.23 AIRFLOW MEASUREMENT SYSTEMS (AIRFLOW MONITORS)

- A. The airflow measurement system (AFMS), including airflow monitor, sensors, controllers, transmitters, etc., indicated on the plans shall be capable of continuously monitoring airflow rates at each measurement location. The system shall consist of one or more airflow measuring devices and a single microprocessor based transmitter. The number of sensing points shall be as per manufacturer's recommendation for the specified application. The AFMS shall not require recalibration or adjustment over the life of the equipment. If the technology provided is vortex shedding or the pitot tube type, the system shall be calibrated on a semi-annual basis during the construction phase through the end of the warranty. The manufacturer is responsible for all cost associated with recalibration.

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- B. Upon request, the manufacturer shall provide for approval and verification a written copy of the following:
1. 16 point NIST traceable report of calibration used for the reference standard.
 2. UL/cUL 873 report listing the AFMS as a complete assembly.
 3. Independent laboratory test report results of 100% survival rate in a 30 day saltwater and acid vapor test.
- C. The AFMS shall produce a single, linear, analog output signal for airflow, which can be measured by the host control system. The system shall have the ability to perform self-diagnostics and automatic zeroing to adjust the signal to zero at pre-determined time intervals, which eliminates all output signal drift due to thermal, electronic and mechanical effects. In the event of sensor failure, the system shall ignore the failed sensor(s), average the remaining sensors and continue to operate.
- D. The total accuracy from the airflow measurement to the host controls, including sensing point averaging error, the sum of the sensor and electronic (transmitter) errors, etc. shall not exceed +/-2% of reading at both minimum and maximum airflow rates based on the manufacturer's published performance specifications for all devices. In addition, total system performance including sampling error, shall not exceed +/-5% of actual airflow. The installed accuracy, in accordance with manufacturer's recommendations, without field adjustment shall be as follows throughout the operating range:
1. Ducts and plenums: +/- 3% of reading
 2. Outside air intakes: +/-5% of reading
 3. Fan inlets: +/- 10% of reading
- E. The sensors and electronics shall operate over a temperature range of -20 to 120°F for ducted supply or return applications and -20 to 120°F for outside air applications. The sensors and electronics shall operate at a relative humidity range of 0 to 95% (non-condensing) for ducted supply and return applications and 0-99% (non-condensing) for outside air applications. Each sensor node shall be individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard and have an accuracy of +/-2% of reading over the entire calibrated airflow range of 0 to 5,000 FPM for ducted applications. Upon request, a working demos shall be provided to the design team to display that the system can work at low flows.
- F. For standard applications, sensors shall be constructed of materials that resist corrosion due to moisture or salt in the airstream. Aluminum probes shall be provided. For laboratory exhaust applications, provide stainless steel sensors with stainless steel casing. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/2CL2P, UL/cUL listed cable rated for exposures from -67°F to 392°F (-55°C to 200°C) and continuous and direct UV exposure. Plenum rated PVC jacket cables are not acceptable. Devices that have electronic signal processing components on or in the sensor probe are not acceptable. Where the electronics are installed in a location exposed to potential wind driven rain or snow (including outside air plenum) provide a

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NEMA 4 enclosure for all electronics. In addition, a visual display shall be provided to illustrate airflow (CFM) and temperature. The transmitter must also be able to display individual sensor reading and each individual flow for each fan on a fan array.

- G. Analog signal capability shall include two output terminals: the first (AO1), shall provide the total airflow rate; while the second output (AO2) shall be field configurable to provide one of the following: temperature, low and/or high airflow user-defined set point alarm, individual fan alarm (for fan arrays) or system status alarm.
- H. Airflow measuring devices shall be UL listed as an entire assembly. The transmitter shall include fused protection.
- I. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans for conformance with installed accuracy requirements. A written report shall be submitted to the consulting mechanical engineer if any measurement locations will not result in specified installed accuracy requirements.
- J. Prior to purchase or installation of the air flow monitor (AFM), the Contractor and/or AFM Product Representative shall review each equipment and/or duct mounted location to verify suitability for installation. Should there be any discrepancy regarding installation or performance, the Contractor shall notify the Engineer immediately.
- K. Provide all necessary power and control wiring as required for a complete and operational air flow measurement system interlocked with the building EMCS. Network communications RS 485 (BACnet MS/TP or Modbus RTU) or Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) shall provide: the average airflow rate, temperature, high and/or low airflow set point alarm, system status alarm, individual sensor node airflow rates (individual fan airflow rates for fan arrays) and individual sensor node temperatures. Individual node airflow rates and temperatures shall be available via the network with Lon.
- L. Airflow measurement system manufacturers shall be limited to the following:
 1. Ebtron (Gold)
 2. Air Monitor Valo-probe with Veltron II transmitter
 3. Tek Aire Vortek VT-5000
 4. Ruskin TDP05K

2.24 FLOW METER

- A. Furnish and install flow meters where indicated on the drawings. Flow meter shall be a dual turbine insertion type flow sensor complete with all installation hardware necessary to enable insertion and removal of the flow meter without system shutdown. The dual turbine element shall have contra-rotating axial turbine elements, each with its own rotational sensing system, and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Paddle type rotors will not be acceptable. Rotational

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- sensing of each turbine shall be accomplished electronically by sensing impedance change and not with magnetic or photo-electric means.
- B. The sensor shall have a maximum operating pressure of 400 PSI, minimum operating pressure of 180°F (optional 300°F peak) and a pressure drop of less than 1 PSI at 17 feet per second flow velocity. Flow sensor shall have a 175:1 turndown ration. Accuracy shall be \pm 0.5% of actual reading at the calibrated typical velocity, and within \pm 2% of reading from 0.4 to 20 ft/s (50:1 turndown). Each sensor shall be individually wet calibrated and tagged accordingly against a primary volumetric standard accurate to within 0.1% and directly traceable to the U.S. National Institute of Standards and Technology (NIST).
 - C. The sensor shall have integral analog outputs of 0-10 VDC and 4-20 mA linear to within \pm 0.1% of calibrated span for connection to the EMCS. The sensor shall also include three (3) integral frequency outputs (top turbine, bottom turbine, average frequency) for diagnostic purposes and for connection to peripheral equipment (local display, BTU meter, etc.). All outputs shall be linear with flow rate.
 - D. The turbine elements shall be constructed of polypropylene (optional polysulfone) with sapphire jewel bearings and tungsten carbide shafts. The flow sensor shall be constructed of plated brass (optional 316 stainless steel with an aluminum electronics enclosure and gasketed cover) (optional weathertight enclosure).
 - E. Flow meter shall be Model F-1210 as manufactured by Onicon or equivalent.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Wiring and Conduit: Provide wiring and conduit to connect the automatic control system components for an operational system.
 - 1. Provide wiring in accordance with requirements indicated in this section.
 - 2. Run conduit in straight lines, parallel to the lines of the building, and rack on factory furnished mounting blocks attached to the building structure. Where run buried in slabs provide long sweep rigid conduit bends extending 6 inches (150 mm) above the slab at slab penetrations.
 - 3. Do not bury or conceal wiring beneath building insulation.
 - 4. Locate wiring clear of access doors, accessible ceilings, lighting fixtures, walkways, or any location subject to damage or abrasion.
- B. Identification: Label or code each field wire at each end, and each controller and controlled device.

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1. Identification shall be permanent, robust, not subject to fading, and flameproof.
 2. Permanently mark terminal blocks at wire termination points.
 3. Identify each control device with an engraved laminated phenolic nameplate, white on black, lettering not less than 1/8-inch (3 mm) height, on 1-1/2-inch (40 mm) by 1-inch (25 mm) tag and brass interlocked chain secured to the control device. Name shall correspond with identification on the shop drawings.
 4. Identify sensors, controllers, relays, either mounted in local or central control panels, or remote mounted with a similar name tag as specified above. Attach to or adjacent to controllers with stainless steel or brass screws or rivets. Adhesives will not be acceptable. Do not attach to removable controller covers.
- C. Pipe Work: Mount strap-on sensors using helical screw stainless steel band clamp for strap-on thermostats, aquastats and other temperature switches on new piping for unit heaters and fan coil units after the pipe is cleaned to bright metal. Strap-on sensor may be used on piping up to 2-1/2-inch (65 mm) diameter. On pipe 3 inches (80 mm) and larger use pipe wells.
- D. Pipe Wells: Install pipe wells above the horizontal to retain liquid heat transfer fluid in the well.
- E. Valves: Install valves in piping with stems as vertical as possible but in no case less than 45 degrees from vertical. For soldered or welded connections, remove valve internals before mounting.
- F. Electric Valves: Wire electric valves in accordance with NFPA 70 with not less than 2 feet (610 mm) of flexible liquidtight connector with watertight bushings at the valve actuator. Brace conduit to the building structure.
- G. Pressure and Temperature Sensors: Install pressure and temperature sensors as follows.
1. Locate pressure and temperature sensing points sufficiently downstream from the control device to increase control loop time constant and minimize hunting.
 2. Locate shut-off valves and 3-valve bypasses as specified in "Sensors" paragraph of this Section.
 3. Locate sensors where accessible for maintenance and replacement.
 4. Do not cover or conceal sensors with insulation.
- H. Space Sensors: Install space sensors as follows.
1. Space sensor including space thermostats, aspirating thermostats, humidistats, pressure or differential pressure sensors shall be enclosed in cast brushed aluminum or 16 gauge (1.6 mm) brushed and ground stainless steel enclosures. Enclosures shall be tamperproof. Setpoint adjustment or settings shall not be

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- visible or adjustable from outside sensor enclosure. Sensors shall be securely mounted and rigid.
2. Locate room thermostats and other room sensors approximately 48 inches (1200 mm) above the floor (or otherwise as required to meet the most current ADA guidelines) on inside wall where they will respond to average conditions in the space.
 3. Sensors mounted on outside walls, if unavoidable, shall be mounted on factory made insulated brushed stainless steel bases.
 4. Provide thermostat/sensor guards in all areas subject to potential damage. Thermostat/sensor guards shall be clear, impact resistant lockable plastic or approved equivalent. Thermostat/sensor guards shall be provided in the following areas and other similar type spaces subject to potential damage: gymnasium, multi-purpose rooms, fitness areas, activity rooms, mechanical rooms, electrical rooms, etc.
- I. Air Handling Unit Temperature Indicators: For each factory assembled central station air handling unit and field erected air handling unit, provide temperature indicators in the following locations.
1. Each outside air plenum.
 2. Each return air plenum.
 3. Each cooling coil inlet and discharge.
 4. Each heating coil discharge.
 5. Temperature indicators shall be so located that they may be read by an operator standing on the operator floor. Indicators more than 8 feet (2400 mm) above the floor shall be remote bulb type.
- J. Duct Sensors: Select duct sensor locations to properly sense average air conditions, minimize vibration, avoid dead air spaces, and within velocity limits required by the manufacturer.
1. Provide velocity shields where required.
 2. Securely mount or clamp averaging elements, maximum 3 feet (900 mm) on centers to the leaving side of coils and equipment. Insulate averaging elements from equipment and protect from vibration.
 3. Provide separate duct flanges for each sensing device.
 4. Provide gaskets or sealant where elements penetrate duct walls.
 5. Mount sensor to allow easy removal and servicing without disturbing insulation or vapor barrier. Mount on standoff brackets to avoid condensation.

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6. Coordinate the location for duct access doors downstream from each duct sensor.
- K. Pipe Sensors: Provide wells for all sensors and indicators measuring temperatures in pressure vessels and piping.
 1. Wells shall be stainless steel or bronze to match media requirements.
 2. Verify working pressure of sensor wells.
 3. Do not install wells in extension couplings.
 4. Where pipe diameters are smaller than the well length, provide wells at piping elbow or tees to affect flow across the entire well area.
 5. Wells may face upstream or downstream.
 6. Angle wells to retain thermal fluid within the well.
 7. Should wells restrict cross sectional pipe area to less than 70 percent free area, provide pipe increases at the well not less than 150 percent pipe diameter.
- L. The ATC contractor shall interface with smoke detectors, smoke dampers and fire alarm devices as required to accomplish equipment shutdown, alarms, etc., as indicated in sequences.
- M. For single phase motors, provide relays and/or contactors of appropriate horsepower and voltage rating as required to energize/de-energize equipment as indicated in sequences.

3.2 TEST PLAN

- A. Test Plan: Prepare a written test plan indicating in a step-by-step, logical fashion, the procedures by which the automatic control system will be tested, adjusted, and checked.
- B. Pre-Approval: Not less than six (6) weeks prior to testing, provide four (4) copies of the proposed test plan for approval. Meet and discuss the test plan, and make agreed changes to the written plan.
- C. Content: Plan shall include, as a minimum, for each system and sub-system of the automatic control work the following:
 1. System name.
 2. List of devices with brief description of functional purpose of each.
 3. A description of the expected signal values transmitted by the sensor.
 4. A description of the expected signal values transmitted by the controller to the control device or actuator.
 5. A description of the expected values of the control medium from limit-to-limit.

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6. A description of the instrumentation required to test the system.
7. A description of the expected field adjustments for transmitter, controller, and control actuator should control parameters fall outside of expected values.
8. A log sheet or sheets on which expected and field read values will be recorded and final field read values indicating that the system is operating in accordance with contract requirements.

3.3 TESTS DURING AND AFTER INSTALLATION

- A. Instrumentation and Control: Calibration test each controller as follows:
 1. Disconnect the sensor input signal to the controller and provide a compatible test signal generator.
 2. Simulate expected transmitter values and input to the controller. Record controller branch line values.
 3. Examine control device and determine that the device is responding.
 4. Simulate maximum and minimum transmitter signal values and verify minimum and maximum controller output values and control device minimum and maximum stroke range.
 5. Record all values and recalibrate controller as necessary to conform with specified control ramps, reset schedule, proportional relationship, reset relationship, and derivative reaction.
 6. When the controller and control device portion of each loop are responding as designed, reconnect the sensor transmitter input line.
 7. After mechanical equipment control becomes operational, perform an operational test of each control loop recording sensor, transmitter, controller input, controller output and control medium parameter.
 8. Entire test shall be witnessed by an owner's representative.
 9. Upon satisfactory test a copy of final test results shall be bound in the operating and maintenance manual.

3.4 FUNCTIONAL PERFORMANCE TESTING AND VERIFICATION

- A. General: In addition to the tests required during and after installation of all mechanical systems, as well as any other formal commissioning requirements, the Contractor shall perform functional performance tests to verify that all systems are designed, installed, calibrated and adjusted to perform as required in the Contract.
- B. Comply with all applicable specification sections including, but not be limited to, "Basic

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- HVAC Requirements", "Testing, Adjusting and Balancing", "Automatic Temperature Controls" and "Commissioning", where applicable.
- C. Prior to functional performance testing, all indicating, recording and control devices shall be calibrated. A verification calibration report shall be provided with the final test report.
 - D. Provide functional performance testing to verify proper operation of each and every control sequence indicated throughout the contract documents.
 - E. Failure of Tests: Should any test, verification, or demonstration fail to meet the specification requirements, the component of the system causing the failure shall be repaired, replaced or readjusted. The failed test, verification, or demonstration shall then be repeated.
 - F. A "Functional Performance Test Verification Form" is included at the end of this section. This form (electronic version is available upon request) shall be completed for all mechanical equipment provided under this contract. This shall include, but not be limited to each air handling unit, fan, pump, VAV terminal, fan coil unit, , DX cooling equipment, miscellaneous heating equipment, etc.
 - G. Test Report: Upon satisfactory verification of calibration and functional performance tests, a copy of the final test results shall be bound in the operations and maintenance manual. The final report shall also include a full compliance statement, on company letterhead, indicating that all systems are installed and functioning per the contract requirements including drawings, specifications, control sequences and accepted submittals.
 - H. The mechanical systems shall not be considered complete until all functional performance verification forms, calibration reports and compliance statement have been submitted and reviewed. Submit in accordance with the submittal requirements indicated elsewhere in these specifications.

3.5 DEMONSTRATION

- A. Demonstration: After completion of testing as hereinbefore specified, provide demonstration to designated operating personnel (refer to Division-01).
 - 1. Demonstration shall be performed.
 - 2. Demonstration shall include the operation of the entire mechanical system under the control of the Contractor and shall include the start-up, operation, and shutdown of the system in accordance with the sequence of operation.
 - 3. The operation of each device shall be performed in accordance with the written instructions contained in the operation and maintenance manual, a copy of which shall be available ten (10) working days prior to the test. No deviation from procedures in the operating manual will be permitted.

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- B. Failure to Perform: Should the system fail to perform in accordance with the requirements of the operation and maintenance manual, the system shall be repaired, recalibrated, retested as necessary, and a second demonstration performed.
1. Subsequent demonstrations shall occur until the automatic control system and all associated mechanical and electrical equipment are operating in accordance with contract requirements.
 2. All testing, retesting, and recalibration shall be at no additional expense. The Contractor shall reimburse the expenses of the commissioning team for each test after the first.

3.6 TRAINING OPERATING PERSONNEL

- A. The Controls Contractor shall provide the following training services:
1. Two days of on-site training, 4 hours each day.
 - a. One four (4) hour training course for the designated AACPS personnel to be performed on job site.
 - b. One four (4) hour training course for the designated AACPS personnel to be performed at the Ft. Smallwood Maintenance office. Time for this training will be adjusted to train AACPS night time personnel.
 - c. The class shall be taught by a Field Engineer who is fully knowledgeable of the specific installation details of the Project.
 - d. Agenda: The course agenda shall be provided by the contractor and shall include instruction on the specific systems and instructions for the operating the installed system. Topics covered should include as a minimum (but not limited to):
 - 1) HVAC System Overview
 - 2) Operation of Control System
 - 3) Function of each Component
 - 4) System Operating Procedures
 - 5) Maintenance Procedures
 - 6) Scheduling
 - 7) Alarm Management
 - 8) Trending
 2. Off-Site Advanced Training:

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- a. Two man-weeks of Advanced Training shall be provided at any time prior to the completion of the warranty period at the controls manufacturer's off-site training facility. Contractor shall pay training registration, materials and miscellaneous fees. Contractor shall also pay for all expenses for travel (travel transportation, meals, lodging, etc.).
 - 1) Advance training shall include the standard, advanced training offering on all control programming applications for the system installed.
 - 2) Advance training shall include the standard, advanced training on installation, configuration, maintenance, network administrator and programming.

3.7 BUILDING MANAGEMENT AND CONTROL SYSTEM DEVICES AND POINTS

- A. Provide all building management and ATC system controllers, devices, points, etc. as required to accomplish the control sequences and equipment functions indicated throughout the contract documents, including drawings and specifications. In addition, provide all controllers, devices, points, etc. as required to control, operate, monitor and alarm all equipment and devices indicated on the contract documents (including but not limited to: chillers, boilers, pumps, air handling units, fans, variable frequency drives, air volume terminal units, valves, dampers, flow measuring devices, sensors, etc.). All points shall be available through the Energy Management Control System (EMCS). See attached points list (where applicable).
- B. Building management and control points shall include status for all mechanical equipment with equipment failures alarmed at the EMCS. In addition, furnish and install all points required to provide complete, color, system graphics of all mechanical systems and components indicated throughout the contract documents. All equipment and devices indicated throughout the contract documents shall be indicated at the operator's workstation (where applicable) and all end devices shall be individually controlled unless specifically indicated otherwise.
- C. Building management and control system features for equipment and devices shall include, but not be limited to, the following where applicable: runtime, trend data, optimal start, scheduling, paging, system graphics, and internet access to graphic and text-based displays.

END OF SECTION 230900

bkm FUNCTIONAL PERFORMANCE TEST VERIFICATION FORM

Project _____

Name: _____

FUNCTIONAL VERIFICATION FOR: _____		<i>(Insert Equipment Name, i.e. Chiller, Boiler, AHU, Fan, Pump, VAV, etc.)</i>			
SEQUENCE OF OPERATION		Controlling as Specified (Y/N)	ATC Technician Initials	Date	Notes
	<i>(Insert complete sequence of operation as indicated in approved ATC submittal)</i>				
	<i>Example: Air Handling Unit Control</i>				
	<i>1. General:</i>				
	<i>1.1 Supply and return fans shall be interlocked. Fans shall operate continuously in the occupied mode. HOA switch shall be in the AUTO position.</i>				
	<i>1.2 Occupied-Unoccupied shall be as determined by the EMCS.</i>				
	<i>2. Temperature Control:</i>				
	<i>2.1 Occupied</i>				
	<i>A. When the outside air enthalpy is above the return air enthalpy, D-1, D-2 and D-3 shall modulate as follows:</i>				

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SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of hydronic piping work is indicated on drawings and schedules, and by requirements of this section and all other Division-23 sections.
- B. Applications for hydronic piping systems include the following:
 - 1. Chilled water supply and return
 - 2. Heating water supply and return

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of hydronic piping products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Installer's Qualifications: Firm with at least five (5) years of successful installation experience on projects with hydronic piping work similar to that required for project.
- C. Codes and Standards:
 - 1. ASME Compliance: Fabricate and install hydronic piping in accordance with ASME B31.9 "Building Services Piping".

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for hydronic piping, materials and products.
- B. Shop Drawings: Submit scaled layout drawings as required by Division-23 Section, "Basic HVAC Requirements".
- C. Record Drawings: At project closeout, submit record drawings of installed hydronic piping and piping products.
- D. Maintenance Data: Submit maintenance data and parts lists for hydronic piping materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual.

PART 2 - PRODUCTS

2.1 MATERIALS AND PRODUCTS

- A. General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, temperature ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide materials and products complying with ASME B31.9 Code for Building Services Piping where applicable, base pressure rating on hydronic piping systems maximum design pressures. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in hydronic piping systems. Where more than one type of materials or products is indicated, selection is Installer's option.

2.2 BASIC IDENTIFICATION

- A. General: Provide identification complying with Division-23 section "Identification for HVAC Piping and Equipment".

2.3 BASIC PIPES AND PIPE FITTINGS

- A. General: Provide pipes and pipe fittings complying with Division-23 section "Pipe, Tube and Fittings for HVAC Systems", in accordance with the following listing:
- B. Hydronic Piping:
1. Tube Size 2" (50 mm) and Smaller: Copper tube; Type L, hard drawn temper; wrought-copper fittings with solder-joints.
 2. Pipe Size 2-1/2" (65 mm) and Larger: Black steel pipe; Schedule 40; wrought-steel buttwelding fittings with welded joints.
 3. Pipe Run within Concrete Construction: Copper tube; Type K, soft annealed temper; no joints or fittings allowed. Sleeve tube with continuous length of 3/8" (10 mm) minimum thickness of flexible unicellular insulation.

2.4 BASIC PIPING SPECIALTIES

- A. General: Provide piping specialties complying with Division-23 section "Piping Specialties for HVAC Systems", in accordance with the following listing:
1. Pipe escutcheons
 2. Pipeline strainers
 3. Dielectric fittings
 4. Drip pans

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5. Sleeves
6. Sleeve seals

2.5 BASIC HANGERS AND SUPPORTS

- A. General: Provide hangers and supports complying with Division-23 section "Hangers and Supports for HVAC Piping and Equipment", in accordance with the following listing:
1. Adjustable steel clevises, adjustable pipe saddle supports, single pipe rolls, and adjustable roller hangers, for horizontal piping hangers and supports.
 2. Two-bolt riser clamps, for vertical-piping clamps.
 3. Steel turnbuckles, for hanger-rod attachments.
 4. Concrete inserts, C-clamps, malleable beam clamps, and steel brackets, for building attachments.
 5. Protection saddles, for saddles and shields.

2.6 BASIC VALVES

- A. General: Provide valves complying with Division-23 section "Valves for HVAC Piping", in accordance with the following listing:
1. Sectional Valves:
 - a. 2" (50 mm) and Smaller: Ball valves.
 - b. 2-1/2" (65 mm) and Larger: Butterfly valves.
 2. Shutoff Valves:
 - a. 2" (50 mm) and Smaller: Ball valves.
 - b. 2-1/2" (65 mm) and Larger: Butterfly valves.
 3. Balancing Valves:
 - a. Combination shut-off/balance valve with venturi type flow meter fitting with integral readout ports and memory stop. Provide ball valve for 2" (50 mm) and smaller, butterfly valve for 2-1/2" (65 mm) and larger.
 - b. See Division-23 section "Hydronic Specialties" for balance valve specification.
 4. Drain Valves:
 - a. 2" (50 mm) and Smaller: Ball valves.

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5. Check Valves:
 - a. All sizes: Swing check valves.

2.7 BASIC EXPANSION COMPENSATION

- A. General: Provide expansion compensation products complying with Division-23 section "Expansion Compensation for HVAC Piping".

2.8 BASIC METERS AND GAUGES

- A. General: Provide meters and gauges complying with Division-23 section "Meters and Gauges for HVAC Piping".

2.9 BASIC VIBRATION CONTROL

- A. General: Provide vibration control products complying with Division-23 section "Vibration Isolation for HVAC Piping and Equipment".

PART 3 - EXECUTION

3.1 INSPECTION

- A. General: Examine areas and conditions under which hydronic piping systems materials and products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF BASIC IDENTIFICATION

- A. General: Install mechanical identification in accordance with Division-23 section "Identification for HVAC Piping and Equipment".

3.3 INSTALLATION OF HYDRONIC PIPING

- A. General: Install hydronic piping in accordance with Division-23 section "Pipe, Tube and Fittings for HVAC Systems".
- B. Install eccentric reducers where pipe is reduced in size in direction of flow, with tops of both pipes and reducer flush.
- C. Connect branch-feed piping to mains at horizontal center line of mains, connect run-out piping to branches at horizontal center line of branches.
- D. Locate groups of pipes parallel to each other, spaced to permit applying full insulation and servicing of valves.

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3.4 INSTALLATION OF PIPING SPECIALTIES

- A. Install piping specialties in accordance with Division-23 section "Piping Specialties for HVAC Systems".

3.5 INSTALLATION OF HANGERS AND SUPPORTS

- A. Install hangers and supports in accordance with Division-23 section "Hangers and Supports for HVAC Piping and Equipment".

3.6 INSTALLATION OF VALVES

- A. Install valves in accordance with Division-23 section "Valves for HVAC Piping".
- B. Sectional Valves: Install on each branch and riser, close to main, where branch or riser serves two (2) or more hydronic terminals or equipment connections, and elsewhere as indicated.
- C. Shutoff Valves: Install on inlet and outlet of each mechanical equipment item, control valves, strainers and elsewhere as indicated.
- D. Balancing Valves: Install on outlet of each hydronic terminal, and elsewhere as indicated.
- E. Drain Valves: Install on each mechanical equipment item and locate to completely drain equipment for service or repair. Install at base of each riser, at base of each rise or drop in piping system, and elsewhere where indicated or required to completely drain hydronic piping system.

3.7 INSTALLATION OF EXPANSION COMPENSATION PRODUCTS

- A. Install expansion compensation products in accordance with Division-23 section "Expansion Compensation for HVAC Piping".

3.8 INSTALLATION OF METERS AND GAUGES

- A. Install meters and gauges in accordance with Division-23 section "Meters and Gauges for HVAC Piping".

3.9 EQUIPMENT CONNECTIONS

- A. General: Connect hydronic piping system to mechanical equipment as indicated, and comply with equipment manufacturer's instructions where not otherwise indicated. Install shutoff valve and union/flange connection on supply and return, and drain valve on drain connection.
- B. Hydronic Terminals: Install hydronic terminals with hydronic terminal valve and union on inlet and outlet. Install manual air vent valve on element in accordance with

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manufacturer's instructions. Locate valves and balancing cocks behind valve access doors for ease of maintenance. Where indicated, install automatic temperature control valve with unions between valve and element on supply line.

3.10 FIELD QUALITY CONTROL

- A. Piping Tests: Test hydronic piping in accordance with testing requirements of Division-23 section "Testing, Adjusting and Balancing."

3.11 CLEANING

- A. Cleaning, Flushing, and Inspecting: Clean, flush, and inspect hydronic piping systems in accordance with requirements of Division-23 section "Pipe, Tube and Fittings for HVAC Systems".

END OF SECTION 232113

SECTION 232115 - HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of hydronic specialties required by this section is indicated on drawings and schedules, and by requirements of this section and all other Division-23 sections.
- B. Types of hydronic specialties specified in this section include the following:
 - 1. Balancing Valves
 - 2. Air Vents
 - 3. Pump Suction Diffusers
 - 4. Multi-purpose Valves
 - 5. Liquid Flow Switches
 - 6. Water Relief Valves
 - 7. Pressure Reducing Valves

1.2 QUALITY ASSURANCE

- A. Hydronic Specialty Types: Provide hydronic specialties of same type by same manufacturer.
- B. Codes and Standards:
 - 1. ASME Compliance: Manufacture and install hydronic specialties in accordance with ASME B31.9 "Building Services Piping".
 - 2. UL and NEMA Compliance: Provide electrical components of hydronic specialties which are listed and labeled by UL, and comply with NEMA standards.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of hydronic specialty. Include pressure drop curve or chart for each type and size of hydronic specialty. Submit schedule indicating manufacturer's figure number, size, location, rated capacities, and features for each required hydronic specialty.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weights, required clearances, and method of assembly of components.

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- C. Maintenance Data: Submit maintenance data and spare parts lists for each type of hydronic specialty. Include this data, product data, and shop drawings in Maintenance Manual.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include the following (unless otherwise noted):
1. Bell and Gossett
 2. Taco
 3. Amtrol
 4. Flow Design, Inc.

2.2 HYDRONIC SPECIALTIES

- A. General: Provide factory-fabricated hydronic specialties recommended for use in service indicated. Provide hydronic specialties of types and pressure ratings indicated for each service, or if not indicated, provide proper selection as determined to comply with installation requirements. Provide sizes as indicated, and connections, which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option, but more than one type cannot be used on project.

2.3 BALANCING VALVES

A. General:

1. Manual balancing devices shall be venturi type as defined by ASHRAE. Devices shall have a precision machined throat and have a stated catalog accuracy of 3% full scale and have an actual accuracy of $\pm 5\%$ of actual reading down to 10 in. w.c. pressure differential across the metering device. The induced differential reading (flow signal) shall be greater than two feet water column at the design flow with the valve in the wide open position. The permanent pressure loss at design flow shall not exceed two feet of water in the wide open position. The valves shall have differential readout ports fitted with check valve and protective cap, and are to have a memory stop to allow complete shut-off and return to set position without losing the setpoint.

B. Construction:

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1. Valves 2" and Smaller: Brass ball valve, blowout proof stem, virgin Teflon seats, brass stems, stem seals and steel handles.
 2. Valves 2-1/2" and Larger: Cast iron butterfly valve, full-lug type with EPDM seat, 416 stainless steel stem, bronze sleeve bearing and bronze disk. Valves 4" and smaller shall have manual lever. Valves 6" and larger shall have gear operated hand wheel.
- C. Minimum Ratings:
1. Devices with sweat or NPT connections: 400 psig (2760 kPa) at 250°F (121°C).
 2. Devices with flanged connections: 125 psig (862 kPa) at 250°F (121°C) suitable for the system for which it is installed.
- D. Readout Meter Kit:
1. Provide a portable readout meter kit by the manufacturer of the balancing devices. The meter shall be permanently mounted in a durable case complete with two 10' (3 m) color coded hoses with shutoff valves at the end that connects to the balance valve so that water does not drain out between readings. Meter shall have a 6" (150 mm) diameter face and 1.75% full rated accuracy. Meter for the venturi type devices shall be provided with a removable transparent face indicating flow directly in GPM for each size device furnished. Meter shall have a three valve manifold for over-range protection.
- E. Installation:
1. The straight pipe required to achieve 3% full scale accuracy shall be incorporated as an integral part of the venturi and valve assembly. No additional straight piping shall be required.
 2. Install in accordance with the manufacturer's instructions.
 3. Check connections after installation for leaks.
- F. Balancing valves shall be Flow Set model UA (2" and smaller) or EF (2-1/2" and larger) as manufactured by Flow Design or equivalent.

2.4 AIR VENTS

- A. Manual Air Vents: Provide manual vents designed to be operated manually with screwdriver or thumbscrew, 1/8" (3 mm) N.P.T. connection.
- B. Automatic Air Vents: Provide automatic vents at all high points of the heating and chilled water systems. All valves shall be cast brass, rated for 150 psig design pressure and 270°F operating temperature. Units to include non-ferrous floats, stainless steel linkage and a Viton seal which closes against a brass spring operated seat. Units shall come complete with a 20 year limited warranty against defects in materials and workmanship, which should be given to owner after installation. Automatic air vents shall be Spirotop

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as manufactured by Spirotherm or equivalent.

2.5 PUMP SUCTION DIFFUSERS

- A. General: Provide pump suction diffusers as indicated. Construct unit with angle pattern cast-iron body, threaded for 2" (50 mm) and smaller, flanged for 2-1/2" (65 mm) and larger, pressure rated for 175 psi (1200 kPa). Provide inlet vanes with length 2-1/2 times pump suction diameter or greater. Provide cylinder strainer with 3/16" (5 mm) diameter openings with total free area equal to or greater than 5 times cross sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head. Provide disposal fine mesh strainer to fit over cylinder strainer. Where available, provide permanent magnet located in flow stream, removable for cleaning. Provide adjustable foot support designed to carry weight of suction piping. Provide blowdown tapping in bottom, gage tapping in side. Provide one extra mesh strainer for each pump suction diffuser.

2.6 MULTI-PURPOSE VALVES

- A. General: Provide pump discharge multi-purpose valves as indicated. Provide nonslam check valve with spring-loaded disc and calibrated adjustment feature permitting regulation of pump discharge flow and shutoff. Design valves to permit repacking under full line pressure, and with bolt-on bonnet. Provide flanged cast-iron valve body, pressure rated for 175 psi (1200 kPa), maximum operating temperature of 240°F (116°C). Provide straight or angle pattern as indicated.
- B. Multi-purpose valves shall have a pressure drop not to exceed 2 psi (14 kPa) at the scheduled pump capacity. Multi-purpose valve size shall not be more than one (1) pipe size less than full line size indicated.

2.7 LIQUID FLOW SWITCHES

- A. General: Provide liquid flow switches as indicated to sense flow and non-flow. Construct of brass for all wetted parts, provide packless construction. Provide paddle with removable segments for pipe size and flow velocity. Provide vapor proof electrical compartment for switches mounted on cold hydronic piping systems. Furnish switches for 115 volt, 60 cycle, single phase, as manufactured by McDonnel and Miller, Inc., or equivalent.

2.8 WATER RELIEF VALVES

- A. General: Provide water relief valves as indicated, of size and capacity as selected by Installer for proper relieving capacity, in accordance with ASME Boiler and Pressure Vessel Code.
1. Combined Pressure-Temperature Relief Valves: Bronze body, test lever, thermostat, adjustable type, complying with ANSI Z21.22 Listing Requirements for temperature discharge capacity. Provide settings to protect the equipment, piping,

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- etc. with the lowest maximum temperature and/or pressure reading.
2. Pressure Relief Valves: Bronze body, test lever, ASME rated, adjustable type. Provide pressure relief settings to protect the equipment, piping, etc. with the lowest maximum pressure rating for each system.

2.9 PRESSURE REDUCING VALVES

- A. General: Provide pressure reducing valves as required, of size and capacity as selected by Installer to maintain operating pressure on system, and as manufactured by Watts or equivalent.
- B. Construction: Cast iron or brass body, low inlet pressure check valve, inlet strainer removable without system shut-down, non-corrosive valve seat and stem, factory set at operating pressure.

PART 3 - EXECUTION

3.1 INSPECTION

- A. General: Examine areas and conditions under which hydronic specialties are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Owner's representative.

3.2 INSTALLATION OF HYDRONIC SPECIALTIES

- A. Balancing Valves: Install venturi type balance valves at all hydronic coils and terminals including, but not limited to, fan coil units, unit ventilators, baseboard radiation, convectors, unit heaters, cabinet heaters, heating coils, cooling coils, etc. For four-pipe terminal units such as fan coil units and unit ventilators, provide balance valves at heating and cooling coil.
- B. Air Vents:
 1. Manual Air Vents: Install manual vents on each hydronic terminal at highest point, and on each hydronic piping drop in direction of flow for mains, branches, and runouts, and elsewhere as indicated. In addition, provide 1/2" ball valve with hose end connection, cap and chain at all high points within the piping system to accommodate manual venting of trapped air.
 2. Automatic Air Vents: Install automatic vents at top of each hydronic riser and elsewhere as indicated. Install shutoff valve between riser and vent valve, pipe outlet to suitable plumbing drain, or as indicated.
- C. Pump Suction Diffusers: Install on pump suction inlet, adjust foot support to carry weight of suction piping. Install full size nipple and shutoff valve in blowdown connection. After cleaning and flushing hydronic piping system, but before balancing of hydronic piping

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- system, remove disposable fine mesh strainer and install permanent strainer.
- D. Liquid Flow Switches: Install liquid flow switches on inlet to water chiller, inlet to water condenser, and elsewhere as indicated. Install in horizontal pipe with switch mounted in tee on top of pipe with minimum of 24" (600 mm) of straight pipe with no fittings both upstream and downstream of switch. Remove segments of paddle to fit pipe in accordance with manufacturer's instructions.
1. Wiring of liquid flow switches is specified in applicable Division-23 sections, and is included as work of this section.
- E. Water Relief Valves: Install on hot water generators, and elsewhere as indicated. Pipe discharge to floor. Comply with ASME Boiler and Pressure Vessel Code.
- F. Pressure Reducing Valves: Install for each system as required, and in accordance with manufacturer's installation instructions.
- G. Multi-Purpose Valves: Provide multi-purpose valves at the discharge of each hydronic pump.
- H. Low Point Drains: Provide a ball valve with hose end connection, cap and chain at all low points within the piping system to accommodated manual draining of water from the system. Drain valves shall be sized in accordance with the following criteria:
1. For pipes smaller than 3", provide 3/4" ball valve.
 2. For pipes 3" – 6", provide 1" ball valve.

END OF SECTION 232115

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SECTION 232123 - HVAC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

- A. Scope: Extent of pump work required by this Section is indicated on the drawings and schedules, and by requirements of this Section and all other Division-23 sections.
- B. Types of pumps specified in this Section include the following:
 - 1. In-line circulator
 - 2. Frame-mounted end-suction

1.2 QUALITY ASSURANCE

- A. Codes and Standards: Provide pumps conforming to the following standards:
 - 1. Hydraulic Institute (HI): Manufacture pumps in accordance with "Standards for Centrifugal Rotary, and Reciprocating Pumps."
 - 2. UL and National Electrical Manufacturers Association (NEMA): Provide electric motors and components which are listed and labeled by UL and comply with NEMA standards. All motors shall be of the premium efficiency type with NEMA enclosures suitable for application.
- B. Certification: Provide pumps whose performances, under specified operating conditions, are certified by the manufacturer.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's pump specifications, installation and start-up instructions, and current pump characteristic performance curves with selection points clearly indicated.
- B. Shop Drawings: Submit manufacturer's shop drawings indicating dimensions, weight loadings, required clearances and methods of assembly of components.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Delivery: Handle pumps carefully to prevent damage, denting and scoring. Do not install damaged pumps or components; replace with new.
- B. Storage: Store pumps and components in a clean, dry place. Protect from weather, dirt, water, construction debris, and physical damage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work shall be limited to the following:
 - 1. Taco
 - 2. Bell and Gossett

2.2 CENTRIFUGAL PUMPS: GENERAL

- A. General: Provide factory tested pumps, thoroughly cleaned, and painted with machinery enamel prior to shipment. Type, size, and capacity of each pump is listed in the pump schedule. Provide pumps of the same type by the same manufacturer.
- B. Non-Overloading: Motor brake horsepower shall not be exceeded at any point of the pump characteristic curve.
- C. Working Pressure: Construct pumps for the working pressure in pounds per square inch specified or 175 psi (1200 kPa) if not indicated. Factory test at 1.5 times working pressure.
- D. Pumps submitted utilizing the largest catalogued impeller diameter on the pump curve will not be acceptable. Provide pumps with an impeller size no larger than 95% of the maximum impeller diameter, and no larger than 85% of the cut water diameter.
- E. All bearings shall have an L10-100,000 hour rating.
- F. Pumps shall have replaceable bronze casing wear ring.

2.3 IN-LINE CIRCULATORS

- A. General: Provide in-line circulators where indicated and of capacities scheduled.
- B. Type: Provide in-line circulators of the horizontal-mount, vertical split-case type, grease lubricated and designed for 125 psi (850 kPa) working pressure and 200°F (93°C) continuous water temperature.
- C. Casings: Construct casings of cast iron with suction and discharge gauge tappings and flanged connections. Provide cast iron companion flanges.
- D. Shafts: Provide hardened alloy steel shafts with copper shaft sleeve.
- E. Bearings: Provide cartridge type bearing assembly.
- F. Seals: Mechanical, with carbon steel ring and ni-resist seat.

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- G. Motors: Provide open, drip-proof motors conforming to NEMA MG 1 with grease lubricated bearings, resilient mounted construction and built-in thermal overload protection on single phase motors.
- H. Couplings: Provide self-aligning, flexible couplings.
- I. Impellers: Provide impellers of the enclosed type, constructed of bronze or stainless steel, hydraulically and dynamically balanced and keyed to the shafts.

2.4 FRAME-MOUNTED END SUCTION PUMPS

- A. General: Provide frame-mounted end-suction pumps where indicated and of capacities and characteristics scheduled.
- B. Type: Provide horizontally mounted pumps of the single stage, base mounted, vertical split case type with flexible couplings. Design for 175 psi (1200 kPa) working pressure.
- C. Casings: Construct casings of cast iron with 125 psi (850 kPa) ANSI flanges and tappings for gauge and drain connections. Provide brass air vent cocks on pumps which are not self-venting.
- D. Shafts: Provide SAE 1045 steel shafts with shaft sleeve and stainless steel shaft nuts.
- E. Bearings: Provide regreasable ball bearings with 100,000 hour life, rated L10 and dust-sealed.
- F. Mechanical Seals: Provide an internally flushed mechanical seal assembly of a carbon rotating assembly and a silicon carbide stationary assembly or a tungsten stationary assembly and a tungsten carbide rotating assembly.
- G. Motors: Provide motors of the open, drip-proof, squirrel cage induction type with regreasable ball bearings, conforming to NEMA MG 1.
- H. Impellers: Provide bronze impellers, enclosed type, hydraulically and dynamically balanced and keyed to the shaft. Secure with sleeve and impeller nuts.
- I. Baseplates: Provide baseplates of structural steel with welded cross members, open grouting area, and drain rim around the entire pump with screwed drain connection. Paint to match pump finish. Provide area in base to allow for grouting after pumps have been piped.
- J. Couplings: Provide flexible couplings, Woods Sureflex or equivalent, capable of absorbing torsional vibration. Equip with ANSI and OSHA compliant coupling guard.
- K. Pump shall be designed to allow for true back pull-out access to the pump's working components without disturbing the system piping.

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2.5 MOTORS (TYPICAL FOR ALL PUMPS)

- A. See Division-23 section, "Electrical Provisions for HVAC Equipment" for minimum motor efficiencies and other requirements.

PART 3 - EXECUTION

3.1 INSTALLATION OF PUMPS

- A. General: Install pumps where indicated and in accordance with manufacturer's published installation instructions.
- B. Support: Install floor mounted pumps on minimum of 4-inch (100 mm) high concrete base. Provide anchor bolts poured in place. Grout pump base level.
- C. Vibration Bases: Refer to Division-23 section, "Vibration Isolation for HVAC Piping and Equipment" for support and mounting requirements of HVAC pumps.

3.2 ADJUSTING AND CLEANING

- A. Alignment: Check alignment and, where necessary, realign shafts of motors and pumps within the recommended tolerances of the manufacturer. For all pumps alignment shall be performed with a dial indicator.
- B. Start-Up: Lubricate pumps before start-up and start-up in accordance with manufacturer's instructions.
- C. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION 232123

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SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of refrigerant piping work is indicated by requirements of this section and all other Division-23 sections.
- B. Refer to requirements of Division-26.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of refrigerant piping products, of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Installer's Qualifications: Specialist with at least five (5) years of successful installation experience on projects with refrigerant piping work similar to that required for project.
- C. Codes and Standards:
 - 1. ASME Compliance: Fabricate and install refrigerant piping in accordance with ASME B31.5, "Refrigeration Piping", and extend applicable lower pressure limits to pressures below 15 psig (100 kPa).
 - 2. IMC Compliance: Fabricate and install refrigerant piping in accordance with "International Mechanical Code".
 - 3. ASHRAE Compliance: Fabricate and install refrigerant piping in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration".

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for refrigerant piping materials and products.
- B. Brazing Certification: Certify brazing procedures, brazers and operators in accordance with ASME standards (ASME B31.5).
- C. Shop Drawings: Submit scaled layout drawings of refrigerant pipe and fittings including, but not necessarily limited to, pipe and tube sizes, locations, elevations and slopes of horizontal runs, wall and floor penetrations, and connections. Show interface and spatial relationship between piping and proximate equipment.
- D. Maintenance Data: Submit maintenance data and parts lists for refrigerant piping materials and products. Include this data, product data, shop drawings, and record

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drawings in maintenance manual.

PART 2 - PRODUCTS

2.1 MATERIALS AND PRODUCTS

- A. General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, temperature ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide materials and products complying with ASME B31.5 Code for Refrigeration Piping where applicable, base pressure rating on refrigerant piping system maximum design pressures. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in refrigerant piping systems. Where more than one type of materials or products are indicated, selection is Installer's option.

2.2 BASIC IDENTIFICATION

- A. General: Provide identification complying with Division-23 sections "Basic HVAC Materials and Methods" and "Identification for HVAC Piping and Equipment", in accordance with the following listing:
1. Refrigerant Piping: Plastic pipe markers.

2.3 BASIC PIPES AND PIPE FITTINGS

- A. General: Provide pipes and pipe fittings complying with Division-23 sections "Basic HVAC Materials and Methods" and "Pipe, Tube and Fittings for HVAC Systems", in accordance with the following listing:
1. Tube Size 4-1/8" (105 mm) and Smaller: Copper tube; Type ACR, hard drawn temper; wrought-copper fittings; brazed joints.
 2. Tube Size 1/2" (13 mm) and Smaller: Copper tube; Type ACR, soft annealed temper; wrought-copper fittings, brazed joints.
 3. Brazed Joints: Braze joints using American Welding Society (AWS) classification BCuP-5 for brazing filler metal.

2.4 BASIC PIPING SPECIALTIES

- A. General: Provide piping specialties complying with Division-23 sections "Basic HVAC Materials and Methods" and "Piping Specialties for HVAC Systems", in accordance with the following listing:
1. Pipe escutcheons

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2. Drip pans
3. Sleeves
4. Sleeve seals

2.5 BASIC HANGERS AND SUPPORTS

- A. General: Provide hangers and supports complying with Division-23 sections "Basic HVAC Materials and Methods" and Hangers and Supports for HVAC Piping and Equipment", in accordance with the following listing:
1. Adjustable steel clevises, adjustable roller hangers, and adjustable pipe roll stands for horizontal piping hangers and supports.
 2. Two-bolt riser clamps for vertical piping supports.
 3. Concrete inserts, C-clamps, and steel brackets for building attachments.
 4. Protection shields for insulated piping support in hangers.
 5. Copper flashings for piping penetrations.

2.6 SPECIAL REFRIGERANT VALVES

- A. General: Special valves required for refrigerant piping include the following types:
1. Globe and Check Valves:
 - a. Globe Shutoff Valves: Forged brass, packed, back seating, winged seal cap, 300°F (149°C) temperature rating, 500 psi (3450 kPa) working pressure.
 - b. Check Valves: Forged brass, accessible internal parts, soft synthetic seat, fully guided brass piston and stainless steel spring, 250°F (121°C) temperature rating, 500 psi (3450 kPa) working pressure.
 2. Solenoid Valves:
 - a. 2-Way Solenoid Valves: Forged brass, designed to conform to ARI 760, normally closed, teflon valve seat, NEMA 1 solenoid enclosure, 24 volt, 60 Hz., UL-listed, 1/2" (13 mm) conduit adapter, 250°F (121°C) temperature rating, 400 psi (2720 kPa) working pressure.
 - 1) Manual Operator: Provide manual operator to open valve.
 3. Ball Valves:
 - a. Ball Valve with Access Port: Compatible with all CFC, HCFC and HFC refrigerants and coils, designed for pressures up to 775 psig, and temperature range of -40°F (-40°C) to 300°F (149°C), full port construction

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to match line size ID, internally equalized ball design, rupture-proof encapsulated stem, UL listed.

- 1) Confirm compatibility with selected VRF/equipment manufacturer.

2.7 REFRIGERANT SPECIALTIES

- A. Refrigerant Strainers: Brass shell and end connections, brazed joints, monel, screen, 100 mesh, UL-listed, 350 psi (2380 kPa) working pressure.
- B. Moisture-Liquid Indicators: Forged brass, single port, removable polished optical glass, solder connections, UL-listed, 200°F (93°C) temperature rating, 500 psi (3450 kPa) working pressure.
- C. Refrigerant Filter-Driers: Steel shell, ceramic fired desiccant core, solder connections, UL-listed, 500 psi (3450 kPa) working pressure.
- D. Refrigerant Filter-Driers: Corrosion-resistant steel shell, steel flange ring and spring, wrought copper fittings, ductile iron cover plate with steel cap screws, replaceable filter-drier core, 500 psi (3450 kPa) working pressure.
- E. Evaporator Pressure Regulators: Provide corrosion-resistant, spring loaded, stainless steel springs, pressure operated, evaporator pressure regulator, in size and working pressure indicated, with copper connections.
- F. Refrigerant Discharge Line Mufflers: Provide discharge line mufflers as recommended by equipment manufacturer for use in service indicated, UL-listed.

2.8 BASIC VIBRATION CONTROL

- A. General: Provide vibration control products complying with Division-23 sections "Basic HVAC Materials and Methods" and "Vibration Isolation for HVAC Piping and Equipment", in accordance with the following listing:
 1. Isolation hangers
 2. Riser isolators
 3. Riser support isolators
 4. Flexible pipe connectors

PART 3 - EXECUTION

3.1 INSPECTION

- A. General: Examine areas and conditions under which refrigerant piping systems materials and products are to be installed. Do not proceed with work until unsatisfactory conditions

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have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF BASIC IDENTIFICATION

- A. General: Install mechanical identification in accordance with Division-23 sections "Basic HVAC Materials and Methods" and "Identification for HVAC Piping and Equipment".

3.3 INSTALLATION OF REFRIGERANT PIPING

- A. General: Install refrigerant piping in accordance with Division-23 sections "Basic HVAC Materials and Methods" and "Pipe, Tube and Fittings for HVAC Systems", and in compliance with equipment manufacturer's recommendations.
- B. Install refrigerant piping with 1/4" per foot (6 mm per meter) (1%) downward slope in direction of oil return to compressor. Provide oil traps and double risers where indicated, and where required to provide oil return.
- C. Clean refrigerant piping by swabbing with dry lintless (linen) cloth, followed by refrigerant oil soaked swab. Remove excess oil by swabbing with cloth soaked in high flash point petroleum solvent, squeezed dry.
- D. Bleed dry nitrogen through refrigerant piping during brazing operations.

3.4 INSTALLATION OF PIPING SPECIALTIES

- A. Install piping specialties in accordance with requirements of Division-23 sections "Basic HVAC Materials and Methods" and "Piping Specialties for HVAC Systems".

3.5 INSTALLATION OF HANGERS AND SUPPORTS

- A. Install supports and anchors in accordance with requirements of Division-23 sections "Basic HVAC Materials and Methods" and "Hangers and Supports for HVAC Piping and Equipment".

3.6 INSTALLATION OF SPECIAL REFRIGERANT VALVES

- A. General: Install refrigerant valves where indicated, and in accordance with manufacturer's instructions. Remove accessible internal parts before soldering or brazing, replace after joints are completed.
 1. Solenoid Valves: Install in refrigerant piping as indicated with stem pointing upwards.
 - a. Wiring of solenoid valves is specified in applicable Division-26 sections, and is included as work of this section.

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3.7 INSTALLATION OF REFRIGERANT ACCESSORIES

- A. Refrigerant Strainers: Install in refrigerant lines as indicated, and in accessible location for service.
- B. Moisture-Liquid Indicators: Install as indicated on refrigerant liquid lines, in accessible location.
- C. Refrigerant Filter-Dryers: Install in refrigerant lines as indicated, and in accessible location for service.
- D. Evaporator Pressure Regulators: Install in refrigerant suction lines or evaporator outlets as indicated. Adjust, if required, for proper evaporator pressure.
- E. Refrigerant Discharge Line Mufflers: Install as indicated, in horizontal or downflow portion of hot-gas lines, immediately after leaving compressor; not in riser.

3.8 EQUIPMENT CONNECTIONS

- A. General: Connect refrigerant piping to mechanical equipment as indicated, and comply with equipment manufacturer's instructions where not otherwise indicated.

3.9 FIELD QUALITY CONTROL

- A. Refrigerant Piping Leak Test: Prior to initial operation, clean and test refrigerant piping in accordance with ASME B31.5, "Refrigeration Piping". Perform initial test with dry nitrogen, using soap solution to test all joints. Refrigerant piping shall be pressure tested and evacuated in accordance with the system manufacturer's recommendations, and /or as follows (whichever is more stringent):
 - 1. Pressure Test (Air Tight Test): Pressurize the suction gas pipe, high/low pressure gas pipe and liquid pipe with dry nitrogen to a minimum pressure as per the system manufacturer. Pressure test duration shall be a minimum of 24 hours. If the pressure does not drop within the 24 hour period, the system passes. If there is a drop in pressure, check for leaks, make repairs and re-test as prescribed above.
 - 2. Evacuation Test (Vacuum Drying): Evacuate the system from the suction gas pipe, high/low pressure gas pipe and liquid pipe to a minimum vacuum pressure as per the system manufacturer. Vacuum pressure shall be maintained in accordance with manufacturer's minimum duration recommended. If it rises, the system may either contain moisture or have leaks, if so, make repairs and re-test as prescribed above.
 - 3. Refer to the Refrigerant Leakage Test Summary Form to document test results. No other form will be acceptable. Submit results for all systems for review.
- B. Repair or replace refrigerant piping as required to eliminate leaks, and retest as specified to demonstrate compliance.

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- C. Refer to Division-23 section "Testing, Adjusting and Balancing" for additional specific test criteria and test form to be completed.

3.10 DEHYDRATION AND CHARGING SYSTEM

- A. Install core in filter dryer after leak test but before evacuation.
- B. Evacuate refrigerant system with vacuum pump, until temperature of 35°F (2°C) is indicated on vacuum dehydration indicator.
- C. During evacuation, apply heat to pockets, elbows, and low spots in piping.
- D. Maintain vacuum on system for minimum of five (5) hours after closing valve between vacuum pump and system.
- E. Break vacuum with refrigerant gas, allow pressure to build up to 2 psi (14 kPa).
- F. Complete charging of system, using new filter dryer core in charging line. Provide full operating charge.

3.11 ADJUSTING AND CLEANING

- A. Cleaning and Inspecting: Clean and inspect refrigerant piping systems in accordance with requirements of Division-23 section "Pipe, Tube and Fittings for HVAC Systems".

END OF SECTION 232300

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SECTION 233113 - LOW PRESSURE DUCTWORK

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of low pressure ductwork is indicated on drawings and in schedules, and by requirements of this section and all other Division-23 sections. Low pressure duct systems shall be defined as those duct systems which have an external static pressure (E.S.P.) of less than two-inches (2") water gauge (wg) (500 Pa). See schedules on drawings for external static pressure information.
- B. Types of low pressure ductwork which may be required for this project include the following:
 - 1. Return air ductwork
 - 2. Outdoor air ductwork (conditioned or unconditioned)
 - 3. Exhaust ductwork
 - 4. Relief ductwork
 - 5.
 - 6. Supply air ductwork (downstream of air terminal units or systems without air terminal units)
 - 7. Air transfer ductwork
- C. Pressure Classification:
 - 1. All ductwork provided under this section shall be "Duct Pressure Class 2" as defined by SMACNA Standards.

1.2 QUALITY ASSURANCE

- A. Installer: A firm with a minimum of five (5) years of successful installation experience on projects with low pressure ductwork systems similar to that required for project.
- B. SMACNA Standards: Comply with latest edition of SMACNA Standards for fabrication, storage and installation of low pressure ductwork. In addition, all new ductwork shall comply with SMACNA's "Duct Cleanliness for New Construction Guidelines." The "Duct Cleanliness Level" for all ductwork shall meet the requirements of the "Advanced Level."
- C. ASHRAE Standards: Comply with ASHRAE Standards for fabrication and installation of low pressure ductwork.

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- D. NFPA Compliance: Comply with ANSI/NFPA 90A "Standard for the Installation of Air-Conditioning and Ventilating Systems" and ANSI/NFPA 90B "Standard for the Installation of Warm Air Heating and Air-Conditioning Systems."
- E. Field Reference Manual: Have available at project field office, copy of SMACNA Standards - latest edition.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's specifications on manufactured products used for work of this section.
- B. Shop Drawings: Submit dimensioned layouts of ductwork showing both the accurately scaled ductwork and its relation to space enclosure as required by Division-23 Section, "Basic HVAC Requirements". Show modifications of indicated requirements, made to conform to local shop practice, and how those modifications ensure that free area, materials, and rigidity are not reduced.
- C. Record Drawings: At project closeout, submit record drawings of installed ductwork, duct accessories, and outlets and inlets.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Protect shop-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings.
- B. All ductwork shall be shipped to the site with covered ends. The ductwork shall be covered with 3-mil (minimum) shrink wrap, with a minimum 2-inch overlap on all sides, to provide a water-tight seal at each opening. The covered ends shall remain intact until installation.
- C. Store ductwork, accessories and purchased products inside and protect from weather.
- D. Ductwork fittings and accessories stored on site for installation shall be covered with protective tarps and elevated a minimum of four inches until installed.
- E. Provide periodic (weekly) photographs of the jobsite storage to document that the ductwork is stored in accordance with the criteria outlined in this specification section.
- F. Lined ductwork not stored in accordance with the above criteria shall be replaced in its entirety. Unlined ductwork not stored in accordance with the above criteria shall be cleaned and inspected by the Owner's representative prior to installation. Contractor shall clean unlined ductwork to the satisfaction of the Owner, or replace at the Owner's discretion.

PART 2 - PRODUCTS

2.1 DUCTWORK MATERIALS

- A. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains and discolorations, and other imperfections, including those which would impair painting. Provide interior lining or double wall duct as indicated on the drawings and/or these specifications.
- B. Sheet Metal: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ANSI/ASTM A 527, lockforming quality, with ANSI/ASTM A 525, G90 zinc coating.

2.2 MISCELLANEOUS DUCTWORK MATERIALS

- A. General: Provide miscellaneous materials and products of types and sizes indicated. Provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.
- B. Duct Liner: Minimum one inch (25 mm) thick (unless otherwise noted) fiberglass, minimum R-value of 4.2 (k-value 0.24 or better), complying with ASTM C 1071, ASTM G 21, ASTM G 22, NFPA 90A, NFPA 90B and UL 181. Duct lining shall contain an EPA registered antimicrobial agent which resists the growth of bacteria and fungi as proven by tests in accordance with ASTM G21 and G22. Liner noise reduction coefficient (NRC) shall be 0.70 or better. Surface of liner shall have water repellent properties. Duct liner shall be Johns Manville Linacoustic RC or equivalent by Certainteed, Knauf or Owens Corning.
- C. Duct Liner Adhesive: Comply with Adhesive and Sealant Council, Inc. (ASC) and ASTM C916.
- D. Duct Liner Fasteners: Comply with SMACNA Standards. Fasteners shall not compress liner by more than 1/8".
- E. Duct Sealant: Non-hardening, non-migrating, oil based mastic or liquid elastic sealant (type applicable for fabrication and installation) as compounded and recommended by manufacturer specifically for sealing joints and seams in ductwork. Sealant shall be solvent (oil) based, water based or silicone based as follows:
 1. Solvent (oil) based sealant shall be used for indoor applications on all new construction installations. In addition, for indoor renovation projects, solvent (oil) based sealant shall be included in the contractor's bid and utilized wherever the sealant odor is not objectionable to the owner. Contractor shall coordinate with the owner's representative prior to the duct installation.
 2. Water based sealant shall be utilized for indoor renovation applications where the odor from solvent (oil) based sealant is objectionable to the owner. Contractor shall coordinate with the owner's representative prior to the duct installation.

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3. Silicone based solvent shall be utilized for all outdoor duct installation applications.
 4. Regardless of duct sealant type, maximum duct leakage requirements outlined in these Division-23 specifications shall be maintained.
- F. Duct Cement: Non-hardening migrating mastic or liquid neoprene based cement (type applicable for fabrication/installation detail) as compounded and recommended by manufacturer specifically for cementing fitting components, or longitudinal seams in ductwork.
- G. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.
1. Except where space is indicated as "High Humidity" area, interior support materials of not less than 1/4" (6 mm) diameter or 3/16" (4.8 mm) thickness may be plain (not galvanized).

2.3 FABRICATION

- A. Shop fabricate ductwork in 4 (1200 mm), 8 (2400 mm), 10 (3000 mm) or 12-foot (3600 mm) lengths, unless otherwise indicated or required to complete runs. Pre-assemble work in shop to greatest extent possible, so as to minimize field assembly of systems. Disassemble systems only to extent necessary for shipping and handling. Match-mark sections for reassembly and coordinated installation.
- B. Shop fabricate ductwork of gauges and reinforcement complying with SMACNA Standards - latest edition.
- C. Shop fabricate ductwork of gauges and reinforcement complying with ASHRAE Standards.
- D. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Except as otherwise indicated, fabricate elbows with center-line radius equal to one and one-half times the associated duct width; and fabricate to include turning vanes in elbows where shorter radius is necessary. Limit angular tapers to 30 degrees for contracting tapers and 20 degrees for expanding tapers.
- E. Fabricate ductwork with accessories installed during fabrication to the greatest extent possible. Refer to Division-23 section "Ductwork Accessories" for accessory requirements.
- F. Fabricate ductwork with duct liner in each section of duct where indicated. Laminate liner to internal surfaces of duct in accordance with instructions by manufacturers of lining and adhesive, and fasten with mechanical fasteners.
- G. Low pressure rectangular ductwork, fittings, etc., shall be constructed, installed and supported in accordance with current SMACNA Standards of gauges not less than the following:

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<u>Maximum Side</u>	<u>Minimum Gauge</u>
Up to 12" (Up to 300 mm)	26 (.5 mm)
13" to 30" (325 mm to 750 mm)	24 (.7 mm)
31" to 60" (775 mm to 1500 mm)	22 (.8 mm)

- H. All factory or shop fabricated ductwork shall be constructed as required to meet the testing requirements indicated in this section and Division-23 section "Testing, Adjusting and Balancing."

2.4 SPIRAL DUCTWORK

- A. Spiral duct shall have locked seams equivalent to United McGill "Uni-Seal," so made as to eliminate any leakage under the pressures for which this system has been designed. Spiral duct shall be manufactured of galvanized steel meeting ASTM A-527 by the spiral lockseam method and in the minimum gauges listed:

<u>Diameter</u>	<u>Minimum Gauge</u>
3" thru 26" (75 mm thru 650 mm)	26 (.5 mm)
28" thru 36" (700 mm thru 900 mm)	24 (.7 mm)

1. 38" thru 50" (950 mm thru 1250) 22 (0.8 mm) All fittings are to have continuous welds along all seams. All divided flow fittings are to be manufactured as separate fittings, not as tap collars welded into spiral duct sections. Fittings and couplings shall be of the following minimum gauges:

<u>Diameter</u>	<u>Minimum Gauge</u>
3" thru 26" (75 mm thru 650 mm)	24 (.7 mm)
28" thru 36" (675 mm thru 900 mm)	22 (1.0 mm)

2. 38" thru 50" (950 mm thru 1250) 20 (1.0 mm) Branch fittings supplying linear bar diffusers shall be "lo-loss" conical type saddle taps.
3. All 90 degree tees and 45 degree laterals, either full size or reducing, shall be conical pattern for 90 degree and straight pattern for 45 degree laterals, produced by machine or press forming. The entrance shall be free of weld build-up, burrs or irregularities. Provide tangential tees where required.
4. Elbows in diameters 3" (75 mm) through 12" (300 mm) shall be two section die-stamped elbows. All other elbows shall be gored construction with all seams continuous-welded. Elbows shall be fabricated to a centerline radius of 1.5 times the cross section diameter. All elbows not die-stamped shall be fabricated according to the following schedule:

<u>Elbow Angle</u>	<u>Number of Gores</u>
Less than 45°	2
46° thru 60°	2
Over 61°	3

5. The reduction of divided flow fittings shall be conical spun section in the thirty-six reductions in sizes 4" (100 mm) through 22" (550 mm).

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6. Spun bellmouth connections shall be used at each round take-off from the high pressure plenum.
7. Offset fittings shall be constructed so that length of offset is not less than two (2) duct diameters.
8. Galvanized areas that have been damaged by welding shall be coated with corrosion resistant aluminum paint, minimum two (2) coats.
9. Supports and sealants shall conform to applicable portions of SMACNA.
10. Flexible ductwork shall be as previously specified for low pressure duct systems.

2.5 FLEXIBLE DUCTWORK

- A. General: Provide insulated flexible ductwork where indicated on drawings, as manufactured by Flex Master Type 6B, or equivalent. Flexible ductwork shall be in compliance with UL-181 Class 1 Air Duct, fabricated with an acoustically transparent nylon inner fabric.
 1. Liner: Nylon fabric, mechanically locked without adhesives.
 2. Helix: Corrosion resistant galvanized steel; formed and mechanically locked to fabric.
 3. Vapor Barrier: Black fire retardant, polyethylene.
 4. Insulation: 1" thick. R-value of 6.0.
 5. Pressure Rating: 6" wg positive.
- B. Sound Attenuation: Flexible ductwork shall have sound attenuating capabilities as indicated below for nominal three feet of straight duct:

Duct Diameter	Insertion Loss (db)						
	63	125	250	500	1000	2000	4000
6	3	9	10	11	12	12	12
8	3	9	9	10	10	12	12
10	3	9	9	9	10	11	10
12	3	9	8	8	9	11	8

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2.6 FRESH AIR INTAKE PLENUMS

- A. Fresh air intake plenums shall be double wall construction (minimum 18 gauge exterior wall, 20 gauge interior wall) with 2" (50 mm) thick, three pound density insulation.

PART 3 - EXECUTION

3.1 INSTALLATION OF DUCTWORK

- A. General: Assemble, install, support and seal ductwork in accordance with recognized industry practices which will achieve air tight (not to exceed 1% leakage) and noiseless (no objectionable noise) systems, capable of performing each indicated service. Install each run with minimum of joints. Align ductwork accurately at connections, within 1/8" (3 mm) misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling.
- B. Seal ductwork to SMACNA Standard Seal Class "A" and provide additional sealant as required to meet duct test requirements of this section.
- C. Install concrete inserts as required, for support of ductwork in coordination with formwork, as required to avoid delays in work.
- D. Complete fabrication of work at project as necessary to match shop-fabricated work and accommodate installation requirements.
- E. Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details and notations or, if not otherwise indicated, run ductwork in shortest route which does not obstruct usable space or block access for servicing building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent-enclosure elements of building. Limit clearance to 1/2" (13 mm) where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1" (25 mm) clearance outside of insulation. Wherever possible in finished and occupied spaces, conceal ductwork from view, by locating in mechanical shafts, hollow wall construction or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.
- F. Electrical Equipment Spaces: Do not run ductwork through transformer vaults and their electrical equipment spaces and enclosures.
- G. Where ducts pass through interior partitions and exterior walls, conceal space between construction opening and duct or duct-plus-insulation with sheet metal flanges of same gauge as duct. Overlap opening on four (4) sides by at least 1-1/2" (40 mm).
- H. Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system.

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- I. Support ductwork in manner complying with SMACNA Standards - latest edition of hangers and supports section.
- J. Unless indicated otherwise, all stainless steel ductwork shall be welded.
- K. Where vapors will be exhausted (dishwasher, cart wash, tunnel wash, canopy hood over sterilizers, etc.), ductwork shall be sloped back toward the source of moisture.
- L. All exposed ductwork (in non-mechanical rooms) shall be primed and painted with paint appropriate for sheet metal surfaces. See architectural section "Painting".
- M. Provide gasketed duct access doors as required to provide maintainable access to the upstream side of coils, humidifiers, etc.

3.2 INSTALLATION OF LINED DUCTWORK

- A. Provide lined ductwork at the following locations, and as otherwise indicated:
 - 1. All ductwork (supply, return, conditioned outside air, DOAS/ERU exhaust return) within the Mechanical Room.
 - 2. All ductwork within 25 feet upstream and downstream of air handling equipment (in all directions, including all duct branches and mains within 25 feet of equipment), including return air fans, with the exception of unconditioned outdoor air intake ductwork.
 - 3. Supply air ductwork downstream of air terminals.
 - 4. All air transfer ductwork, unless otherwise indicated.
- B. Dimensions on drawings indicate inside clear dimensions.
- C. Fiberglass liner exposed to the air stream shall not be utilized for outdoor air intake ductwork.
- D. Where ductwork is exposed to view in occupied areas, rectangular ductwork shall be lined and round ductwork shall be double wall duct with internal lining, unless otherwise noted.

3.3 INSTALLATION OF FLEXIBLE DUCTWORK

- A. Where indicated, provide factory insulated flexible ductwork between low pressure supply ductwork and round inlet ceiling diffusers. Provide side take-off fitting with damper (Flexmaster USA, model STOD or equivalent) between the flexible duct and the low pressure supply ductwork. Extend rigid sheet metal ductwork between the fitting and the flexible ductwork as required. The maximum length of flexible duct shall be 3'- 0" (915 mm).
- B. Connections to round neck diffusers shall include a rigid 45 degree sheet metal elbow at

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the diffuser inlet.

3.4 CLEANING AND PROTECTION

- A. Prior to installation, thoroughly clean ductwork internally of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or might interfere with painting or cause paint deterioration.
- B. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, install sheet metal temporary closures which will prevent entrance of dust and debris until the time all connections are to be completed.
- C. Provide MERV 13 filter media at all return air inlet locations throughout the duration of construction. Filter media shall not be removed until final filters are installed in the air handling units.

3.5 DUCT TESTING

- A. Prior to the balancing of systems by the AABC certified balancing contractor, all low pressure ductwork shall be tested by the mechanical contractor for duct leakage. Duct leakage shall not exceed 1%. In addition, current SMACNA and AABC Standards shall apply, where applicable, to meet the maximum 1% leakage. Duct leakage shall not exceed 1% of design cfm for a duration of ten (10) minutes. Test pressures shall be not less than the following:
 1. Ductwork systems less than 2.0 in. wg E.S.P.: Test to 2 in. wg
- B. Insulation materials shall not be applied until systems have been witnessed, documented, and submitted to meet the above testing requirements.
- C. The balance contractor shall witness and certify all duct pressure tests.
- D. Contractor shall submit duct leakage test results to the A/E within 72 hours of completed tests. Only test results that meet the specified leakage requirements shall be submitted. Duct test results shall be recorded on the "Air Duct Leakage Test Summary Form" located at the end of Section 230593; no other forms will be accepted. In addition, the duct leakage submittals shall include 11x17 drawing(s) as required to clearly indicate the full extent of the duct test section (each duct test section shall be numbered and color coded).
- E. All duct leakage test results shall be included with the final TAB report and the O&M Manual. The orifice tube calibration chart shall also be included with the final duct leakage test report information.

3.6 BALANCING

- A. Refer to Division-23 section "Testing, Adjusting and Balancing" for air distribution

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balancing of low pressure ductwork; not work of this section.

END OF SECTION 233113

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SECTION 233114 - HIGH PRESSURE DUCTWORK

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of high pressure ductwork is indicated on drawings and in schedules and by requirements of this section and all other Division-23 sections. High pressure duct systems shall be defined as those duct systems which have an external static pressure (E.S.P.) of two-inches (2") water gauge (wg) (500 Pa) or greater. In addition, all ductwork upstream of terminal units shall be classified as high pressure. See schedules on drawings for external static pressure information.
- B. Types of high pressure ductwork which may be required for this project include the following:
 - 1. Supply air ductwork (upstream of terminal units i.e. from air handling unit to air terminals).
- C. Pressure Classification
 - 1. For ductwork systems with external static pressure between 2.0 in. wg and 5.0 in. wg: Ductwork provided shall be "Duct Pressure Class 6" as defined by SMACNA Standards.
 - 2. For ductwork systems with external static pressure between 5.0 in. wg and 10.0 in. wg: Ductwork provided shall be "Duct Pressure Class 10" as defined by SMACNA Standards.

1.2 QUALITY ASSURANCE

- A. Installer: Work shall be performed by a firm with a minimum of five (5) years of successful experience on projects with high pressure ductwork systems similar to that required for project.
- B. SMACNA Standards: Comply with latest edition of SMACNA Standards for fabrication, storage, and installation of high pressure ductwork. In addition, all new ductwork shall comply with SMACNA's "Duct Cleanliness for New Construction Guidelines." The "Duct Cleanliness Level" for all ductwork shall meet the requirements of the "Advanced Level."
- C. ASHRAE Standards: Comply with ASHRAE Standards for fabrication and installation of high pressure ductwork.
- D. NFPA Compliance: Comply with ANSI/NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" and ANSI/NFPA 90B "Standard for the Installation of Warm Air Heating and Air Conditioning Systems."

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- E. Field Reference Manual: Have available at project field office copy of SMACNA Standards - latest edition.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's specifications on manufactured products and factory-fabricated ductwork used for work of this section.
- B. Shop Drawings: Submit dimensioned layouts of ductwork showing both the accurately scaled ductwork and its relation to space enclosure as required by Division-23 Section, "Basic HVAC Requirements". Show modifications of indicated requirements made to conform to local shop practice and how those modifications ensure that free area materials and rigidity are not reduced.
- C. Record Drawings: At project closeout, submit record drawings of installed ductwork, duct accessories, and outlets and inlets.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Protect shop-fabricated and factory-fabricated ductwork accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings.
- B. All ductwork shall be shipped to the site with covered ends. The ductwork shall be covered with 3-mil (minimum) shrink wrap, with a minimum 2-inch overlap on all sides, to provide a water-tight seal at each opening. The covered ends shall remain intact until installation.
- C. Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclose with waterproof wrapping.
- D. Ductwork fittings and accessories stored on site for installation shall be covered with protective tarps and elevated a minimum of four inches until installed.
- E. Provide periodic (weekly) photographs of the jobsite storage to document that the ductwork is stored in accordance with the criteria outlined in this specification section.
- F. Lined ductwork not stored in accordance with the above criteria shall be replaced in its entirety. Unlined ductwork not stored in accordance with the above criteria shall be cleaned and inspected by the Owner's representative prior to installation. Contractor shall clean unlined ductwork to the satisfaction of the Owner, or replace at the Owner's discretion.

PART 2 - PRODUCTS

2.1 DUCTWORK MATERIALS

- A. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains and discolorations, and other imperfections, including those which would impair painting. Provide interior lining or double wall duct as indicated on the drawings and/or these specifications.
- B. Sheet Metal: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ANSI/ASTM A 527, lockforming quality with ANSI/ASTM A 525, G90 zinc coating.

2.2 MISCELLANEOUS DUCTWORK MATERIALS

- A. General: Provide miscellaneous materials and products of types and sizes indicated. Provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.
- B. Duct Liner: Minimum one inch (25 mm) thick (unless otherwise noted) fiberglass, minimum R-value of 4.2 (K-value 0.24 or better), complying with ASTM C 1071, ASTM G 21, ASTM G 22, NFPA 90A, NFPA 90B and UL 181. Duct lining shall contain an EPA registered antimicrobial agent which resists the growth of bacteria and fungi as proven by tests in accordance with ASTM G21 and G22. Liner noise reduction coefficient (NRC) shall be 0.70 or better. Surface of liner shall have water repellent properties. Duct liner shall be Johns Manville Linacoustic RC or equivalent by Certainteed, Knauf or Owens Corning.
- C. Fittings: Provide radius type fittings fabricated of multiple sections with maximum 15° change of direction per section, unless specifically detailed otherwise. Use 45° straight type laterals and 45° elbows for branch take-off connections. Where 90° branches are indicated, provide conical type tees.
- D. Duct Sealant: Non-hardening, non-migrating, oil based mastic or liquid elastic sealant (type applicable for fabrication and installation) as compounded and recommended by manufacturer specifically for sealing joints and seams in ductwork. Sealant shall be solvent (oil) based, water based or silicone based as follows:
 1. Solvent (oil) based sealant shall be used for indoor applications on all new construction installations. In addition, for indoor renovation projects, solvent (oil) based sealant shall be included in the contractor's bid and utilized wherever the sealant odor is not objectionable to the owner. Contractor shall coordinate with the owner's representative prior to the duct installation.
 2. Water based sealant shall be utilized for indoor renovation applications where the odor from solvent (oil) based sealant is objectionable to the owner. Contractor shall coordinate with the owner's representative prior to the duct installation.

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3. Silicone based solvent shall be utilized for all outdoor duct installation applications.
 4. Regardless of duct sealant type, maximum duct leakage requirements outlined in these Division-23 specifications shall be maintained.
- E. Duct Cement: Non-hardening, migrating mastic or liquid neoprene based cement (type applicable for fabrication/installation detail) as compounded and recommended by manufacturer specifically for cementing fitting components or longitudinal seams in ductwork.
- F. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.
1. Except where space is indicated as "High-Humidity" area, interior support materials of not less than 1/4" (6 mm) diameter or 3/16" (4.8 mm) thickness may be plain (not galvanized).

2.3 FABRICATION

- A. Shop fabricate rectangular ductwork in 4 (1200 mm), 8 (2400 mm), 10 (3000 mm) or 12-foot (3600 mm) lengths, unless otherwise indicated or required to complete runs. Pre-assemble work in shop to greatest extent possible so as to minimize field assembly of systems. Disassemble systems only to extent necessary for shipping and handling. Match-mark sections for reassembly and coordinated installation.
- B. Shop fabricate ductwork of gauges and reinforcement complying with SMACNA Standards - latest edition.
- C. Shop fabricate ductwork of gauges and reinforcement complying with ASHRAE Standards.
- D. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings, except as otherwise indicated. Fabricate elbows with center-line radius equal to one and one-half times the associated duct width. Limit angular tapers to 30° for contracting tapers and 20° for expanding tapers.
- E. Fabricate ductwork with accessories installed during fabrication to the greatest extent possible. Refer to Division-23 section "Ductwork Accessories" for accessory requirements.
- F. All factory or shop fabricated ductwork shall be constructed as required to meet the testing requirements of this section and Division-23 section "Testing, Adjusting and Balancing."

2.4 FACTORY-FABRICATED DUCTWORK

- A. General: Provide factory-fabricated duct and fittings as indicated, or as installer's option in lieu of shop fabricated duct and fittings.

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- B. Round Ductwork: Construct of galvanized sheet steel complying with ANSI/ASTM A 527 by the following methods and in minimum gauges listed.

<u>1.</u>	<u>Duct Diameter</u>	<u>Minimum Gauge</u>	<u>Method of Manufacture</u>
	3" to 14" (75 mm to 300 mm)	26 (.5 mm)	Spiral Lockseam
	15" to 26" (375 mm to 650 mm)	24 (.7 mm)	Spiral Lockseam
	28" to 36" (700 mm to 850 mm)	22 (.8 mm)	Spiral Lockseam
	38" to 50" (900 mm to 1250 mm)	20 (1.0 mm)	Spiral Lockseam

2. Provide locked seams for spiral duct; fusion-welded butt seam for longitudinal seam duct.
3. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous welds along seams.

<u>a.</u>	<u>Duct Diameter</u>	<u>Minimum Gauge</u>
	3" to 14" (75 mm to 300 mm)	24 (.7 mm)
	15" to 26" (325 mm to 650 mm)	22 (.8 mm)
	28" to 50" (700 mm to 1250 mm)	20 (1.0 mm)

4. 50" to 60" (1250 mm to 1500 mm) 18 (1.6 mm) Inner Liner: Where indicated, provide inner liner, perforated with 3/32" (2.5 mm) holes for 22% open area. Provide metal spacers welded in position to maintain spacing and concentricity. Inner liner shall be as follows:
- a. Ductwork: Up to 62" diameter, 26 gauge; over 62" diameter, 22 gauge.
- b. Fittings: Up to 35" diameter, 24 gauge; over 35" diameter, 22 gauge.

- C. Flat-Oval Ductwork: Construct of galvanized sheet steel complying with ANSI/ASTM A 527 of spiral lockseam construction in minimum gauges listed.

<u>Duct Width</u>	<u>Minimum Gauge</u>	<u>Method of Manufacture</u>
Up to 24" (Up to 600 mm)	24 (.7 mm)	Spiral Lockseam
25" to 48" (625 mm to 1200 mm)	22 (.8 mm)	Spiral Lockseam

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1. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous weld along seams.

a.	<u>Duct Width</u>	<u>Minimum Gauge</u>
	Up to 36" (Up to 900 mm)	20 (1.0 mm)
	37" to 60" (925 mm to 1500 mm)	18 (1.3 mm)

2. Inner Liner: Where indicated, provide inner liner, perforated with 3/32" (2.5 mm) holes for 22% open area. Provide metal spacers welded in position to maintain spacing and concentricity. Inner liner shall be as follows:

- a. Ductwork: Up to 60" duct width, 26 gauge; over 60" duct width, 22 gauge.
- b. Fittings: Up to 35" width, 24 gauge; over 35" width, 22 gauge.

PART 3 - EXECUTION

3.1 INSTALLATION OF DUCTWORK

- A. General: Assemble, install and seal ductwork in accordance with recognized industry practices which will achieve air tight (not to exceed 1% leakage) and noiseless (no objectionable noise) systems, capable of performing each indicated service. Install each run with minimum of joints. Align ductwork accurately at connections within 1/8" (3 mm) misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling.
- B. Supply ductwork within the mechanical equipment rooms shall be double walled, internally insulated (minimum 1" lining) (minimum 25 mm lining) with perforated galvanized liner. Ductwork (supply, return, DOAS/ERU exhaust return) outside of mechanical equipment rooms and within 25 feet (7500 mm) (in all directions, including all duct branches and mains within 25 feet of equipment) from each air handling unit shall also be double walled, internally insulated (minimum 1" lining) (minimum 25 mm lining) with perforated galvanized liner.
- C. Round spiral ductwork shall be connected to the terminal units. Where duct diameter and box inlet differ, provide concentric factory fabricated high velocity adapters.
- D. Seal all ductwork in accordance with Seal Class "A" SMACNA Standards - Latest Edition, and provide additional sealant as required to meet duct leak test requirements of this section.
- E. Install concrete inserts, as required, for support of ductwork in coordination with formwork as required to avoid delays in work.
- F. Complete fabrication of work at project as necessary to match shop-fabricated work and accommodate installation requirements.

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- G. Locate ductwork runs except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details and notations or if not otherwise indicated. Run ductwork in shortest route which does not obstruct usable space or block access for servicing building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent-enclosure elements of building. Limit clearance to 1/2" (13 mm) where furring is shown for enclosure or concealment of ducts but allow for insulation thickness, if any. Where possible locate insulated ductwork for 1" (25 mm) clearance outside of insulation. Wherever possible in finished and occupied spaces conceal ductwork from view by locating in mechanical shafts, hollow wall construction or above suspended ceilings. Do not encase horizontal runs in solid partitions except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.
- H. Where ductwork is exposed to view in occupied areas, duct shall be double wall duct with internal lining, unless otherwise noted.
- I. Electrical Equipment Spaces: Do not run ductwork through transformer vaults and other electrical equipment spaces and enclosures.
- J. Where ducts pass through interior partitions and exterior walls, conceal space between construction opening and duct or duct-plus-insulation with sheet metal flanges of same gauge as duct. Overlap opening on four (4) sides by at least 1-1/2" (40 mm).
- K. Coordinate duct installations with installation of accessories, dampers, coil frames, equipment controls and other associated work of ductwork system.
- L. Support ductwork in manner complying with SMACNA Standards - latest edition of hanging and supporting systems chapter.
- M. All exposed ductwork (in non-mechanical rooms) shall be primed and painted with paint appropriate for sheet metal surfaces. See architectural section "Painting".
- N.

3.2 CLEANING AND PROTECTION

- A. Prior to installation, thoroughly clean ductwork internally of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or might interfere with painting or cause paint deterioration.
- B. Strip protective paper from stainless steel ductwork surfaces and repair finish wherever it has been damaged.
- C. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, install sheet metal temporary closures which will prevent entrance of dust and debris until the time all connections are to be completed.

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3.3 DUCT TESTING

- A. Prior to the balancing of systems by the AABC certified balancing contractor, all high pressure ductwork shall be tested by the mechanical contractor for duct leakage. Duct leakage shall not exceed 1%. In addition, current SMACNA and AABC Standards shall apply, where applicable, to meet the maximum 1% leakage. Duct leakage shall not exceed 1% of design cfm for a duration of ten (10) minutes. Test pressures shall be not less than the following:

Ductwork systems between 2.0 in. wg and 5.0 in. wg E.S.P.: Test to 6 in. wg

Ductwork systems greater than 5.0 in. wg E.S.P.: Test to 10 in. wg

Insulation materials shall not be applied until systems have been witnessed, documented, and submitted to meet the above testing requirements.

- B. The balance contractor shall witness and certify all duct pressure tests.
- C. Contractor shall submit duct leakage test results to the A/E within 72 hours of completed tests. Only test results that meet the specified leakage requirements shall be submitted. Duct test results shall be recorded on the "Air Duct Leakage Test Summary Form" located at the end of Section 230593; no other forms will be accepted. In addition, the duct leakage submittals shall include 11x17 drawing(s) as required to clearly indicate the full extent of the duct test section (each duct test section shall be numbered and color coded).
- D. All duct leakage test results shall be included with the final TAB report and the O&M Manual. The orifice tube calibration chart shall also be included with the final duct leakage test report information.

3.4 BALANCING

- A. Refer to Division-23 section "Testing, Adjusting and Balancing" for air distribution balancing of high pressure ductwork; not work of this section.

END OF SECTION 233114

SECTION 233300 - DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of ductwork accessories work is indicated on drawings and in schedules, and by requirements of this section and all other Division-23 sections.
- B. Types of ductwork accessories required for project include the following:
 - 1. Dampers:
 - a. Low pressure manual dampers
 - b. Control dampers
 - 2. Fire and smoke dampers
 - 3. Turning vanes
 - 4. Duct hardware
 - 5. Duct access doors
 - 6. Flexible connections
 - 7. Penetration seals
 - 8. Duct silencers
- C. Duct Cleaning: Each of the following HVAC systems listed shall be cleaned and sanitized in their entirety:
 - 1. All existing supply ductwork associated with renovated spaces and/or systems
 - 2. All existing return ductwork associated with renovated spaces and/or systems
 - 3. All existing exhaust ductwork and fans associated with renovated spaces and/or systems
 - 4. All existing air handling units and associated fans associated with renovated spaces and/or systems

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1.2 QUALITY ASSURANCE

A. Codes and Standards:

1. SMACNA Compliance: Comply with applicable portions of latest edition of SMACNA Standards. In addition, all duct accessories shall comply with SMACNA's "Duct Cleanliness for New Construction Guidelines." The "Duct Cleanliness Level" for all ductwork shall meet the requirements of the "Advanced Level."
2. Industry Standards: Comply with ASHRAE recommendations pertaining to construction of ductwork accessories, except as otherwise indicated.
3. UL Compliance: Construct, test, and label fire, smoke and combination fire/smoke dampers in accordance with UL Standards 555 and 555S.
4. NFPA Compliance: Comply with applicable provisions of NFPA 90A "Air Conditioning and Ventilating Systems", pertaining to installation of ductwork accessories.

B. Duct Cleaning Contractor:

1. Duct cleaning contractor shall have been regularly engaged in commercial type duct cleaning services for a minimum of five (5) years of successful operation.
2. NADCA Certified: The duct cleaning contractor shall be certified by the National Air Duct Cleaners Association (NADCA).

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data for each type of ductwork accessory, including dimensions, capacities, materials of construction and installation instructions.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of ductwork accessory showing interfacing requirements with ductwork, method of fastening or support, and methods of assembly of components.
- C. Maintenance Data: Submit manufacturer's maintenance data including parts lists for each type of duct accessory. Include this data, product data, and shop drawings in maintenance manual.
- D. Duct cleaning contractor shall submit proposed approach, methodology and detailed cleaning and sanitizing process for each system listed above for approval prior to work being performed. In addition, provide documentation of NADCA certification, as well as five (5) years of successful performance.

PART 2 - PRODUCTS

2.1 DAMPERS

- A. Low Pressure Manual Dampers: Provide dampers of single blade type or multiblade type, constructed in accordance with the latest edition of SMACNA Standards. Provide damper extender rods as required to compensate for external duct insulation.
- B. Control Dampers: Refer to Division-23 section "Automatic Control Systems" for control dampers; not work of this section.
- C. Counterbalanced Dampers: Provide dampers with parallel blades, counterbalanced and factory-set to relieve at indicated static pressure. Construct blades of 16-gauge (1.6 mm) aluminum. Provide 1/2" (13 mm) diameter ball bearings, 1/2" (13 mm) diameter steel axles spaced on 9" (230 mm) centers. Construct frame of 2" x 1/2" x 1/8" ((50 mm x 13 mm x 3 mm) steel channel for face areas 25 sq. ft. (2.3 m²) and under; 4" x 1-1/4" x 16-gauge (100 mm x 30 mm x 1.6 mm) channel for face areas over 25 sq. ft. (2.3 m²). Provide galvanized steel finish on frame with aluminum touch-up.

2.2 FIRE AND SMOKE DAMPERS

- A. Fire Dampers: Provide fire dampers where indicated and where required by NFPA and local authorities. Provide Type "C" fire dampers. Construction shall be in accordance with NFPA 90A and UL 555, and be UL labeled accordingly. Provide fusible link rated at 160°F to 165°F (71°C to 74°C) unless otherwise indicated. Provide damper with positive lock in closed position. Damper blades shall be fully out of the air stream. Horizontal installations shall have damper blades and closure spring out of air stream. Provide the following features:
 1. Damper Blade Assembly: Curtain or multiple blade type.
 2. Blade Material: Match casing and ductwork where installed.
 3. Provide factory sleeve. Construction shall be minimum 20 gauge. Should duct be heavier than 20 gauge, provide sleeve and frame to match duct and material construction. Sleeves shall be sufficient in length to protrude on both sides of the wall to allow for access door on one side and UL approved breakaway duct connection on both sides.
- B. Motor Driven Combination Fire/Smoke Dampers: Provide motor driven fire/smoke dampers in types and sizes indicated and where required by NFPA and local authorities as indicated on the drawings. Dampers shall be multi-blade type with frames and blades constructed of galvanized steel. Dampers shall be UL 555 and 555S listed with Class I leakage characteristics at 250°F (8 CFM/ft² at 4" WG). Dampers located in medium pressure systems shall have air foil blades. Dampers in low pressure systems are to be

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standard "V" groove type. Dampers shall have factory sleeves meeting the requirements of UL. Electric actuators shall be provided by the damper manufacturer and installed at the factory externally on the damper sleeve. Actuators shall be UL approved as an assembly with the damper. Provide end position indicator switches for use by ATC. Duct type smoke detectors shall be furnished under Division-28.

1. Coordinate the damper voltage with the smoke/duct detector relay voltage.
 2. See drawings for additional information regarding wiring of smoke and fire/smoke dampers.
- C. Dampers shall be as manufactured by Ruskin, Greenheck, Nailor, Air Balance, Pottorff, or United Enertech, subject to compliance with requirements indicated.

2.3 TURNING VANES

- A. Manufactured Turning Vanes: Provide turning vanes constructed of 1-1/2" (40 mm) wide curved blades set at 3/4" o.c. (20 mm), supported with bars perpendicular to blades set at 2" o.c. (50 mm), and set into side strips suitable for mounting in ductwork.

2.4 DUCT HARDWARE

- A. General: Provide duct hardware, manufactured by one manufacturer for all items on project, for the following:
1. Test Holes: Provide duct test holes in ductwork at fan inlet and outlet, and elsewhere as indicated, consisting of slot and cover, for instrument tests.
 2. Quadrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12" (300 mm). Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

2.5 DUCT ACCESS DOORS

- A. General: Provide duct access doors where required for duct accessory access. Provide access doors for fire dampers, smoke dampers and smoke detectors. Install access doors upstream of duct type smoke detectors.
- B. Construction: Construct of same or greater gage as ductwork served and provide insulated doors for insulated ductwork. Provide flush frames for uninsulated ductwork and extended frames for externally insulated duct. Provide one side hinged, other side with one handle-type latch for doors 12" (300 mm) high and smaller, 2 handle-type latches for larger doors.

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2.6 FLEXIBLE CONNECTIONS

- A. General: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flame retardant fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibrations of connected equipment.

2.7 PENETRATION SEALS

- A. Provide seals for all openings through fire-rated walls, floors or ceilings used as passage for mechanical components such as ductwork. See Division-23 section "Basic HVAC Materials and Methods" for penetration seals and firestopping requirements.
- B. Provide seals for all openings through walls, floors or ceilings used as passage for mechanical components such as ductwork.

2.8 DUCT SILENCERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work, shall be limited to the following:
1. Price
 2. Vibro Acoustics
 3. Semco
- B. General
1. Silencers shall be of the size, configuration, capacity and acoustic performance as scheduled on the drawings. Silencers shall be fabricated by the same manufacturer.
 2. Silencer inlet and outlet connection dimensions must be equal to the duct sizes shown on the drawings.
- C. Construction:
1. Silencers shall be constructed in accordance with ASHRAE and SMACNA Standards for the pressure and velocity classification specified for the air distribution system in which it is installed.
 2. Casing seams and joints shall be lock-formed and sealed or stitch welded and sealed except as noted, to provide leakage-resistant construction.

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3. Airtight construction shall be achieved by use of a duct-sealing compound supplied and installed by the contractor at the jobsite.
 4. Perforated steel shall be adequately stiffened to insure flatness and form. Spot welds shall be painted as required.
 5. Fire-Performance Characteristics:
 - a. Silencer assemblies, including acoustic media fill, natural cotton fiber, sealants and acoustical spacers shall have Class 1 flame- spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E84, NFPA 255 or UL 723.
 6. Material gauge thickness:
 - a. Material gauges noted in other sections are minimums and shall increase as required for the system pressure and velocity classification.
 - b. The silencers shall not fail structurally when subjected to a differential air pressure of 8 inches water gauge.
- D. Outer casing shall be ASTM A 653/A 653M, G90 galvanized sheet steel, gauge as listed below:
1. Rectangular Silencers, including STC-rated models: 22 gauge
 2. Rectangular Elbow Silencers: 22 gauge
 3. Circular Silencers:
 - a. For units up to 20 inches in diameter: 22 gauge
 - b. For units 21 through 44 inches in diameter: 18 gauge
- E. Rectangular Elbow Silencers:
1. Acoustical splitter/baffles shall be internally radiused and aerodynamically designed for efficient turning of the air.
- F. Inner perforated metal liner shall be supplied in accordance with ASTM A 653/A 653M, G90 galvanized sheet steel in the following gauge thicknesses according to silencer type or connection size:
1. Rectangular Silencers: 22 gauge
 2. Rectangular Elbow Silencers: 22 gauge
 3. Circular Silencers: 22 gauge

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G. Principal Sound-Absorbing Mechanism:

1. Standard Acoustic media:

- a. Media shall be of acoustic quality, shot-free glass fiber insulation with long, resilient fibers bonded with a thermosetting resin. Glass fiber density and compression shall be as required to insure conformance with laboratory test data.
- b. Media shall be packed with a minimum of 15% compression during silencer assembly.
- c. Media shall be resilient such that it will not pull apart during normal applications, and shall resist settling, breakdown, and sagging from vibration. Media shall not rot, mildew, or otherwise deteriorate, and shall have sufficient flexibility to readily form around corners and curved surfaces.
- d. Media shall not cause or accelerate corrosion of aluminum or steel.

H. Media Protection:

1. Dissipative silencers:

- a. Where indicated on the silencer schedule, media shall be encapsulated in glass fiber cloth to help prevent shedding, erosion and impregnation of the glass fiber.
- b. Axial Fan silencers shall have a glass fiber cloth liner.

I. Shipping Protection:

1. Silencers shall be shipped with factory-installed end caps.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which ductwork accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF DUCTWORK ACCESSORIES

- A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended

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- function.
- B. Provide fire dampers where ducts penetrate a floor slab, and elsewhere as indicated.
 - C. Install balancing dampers where indicated, and at each ducted air inlet and outlet. Dampers are not required where a single air outlet occurs downstream of an air terminal (VAVs, fan powered boxes, etc.).
 - D. Install turning vanes in square or rectangular elbows (45 degrees and greater) in supply, return and exhaust air systems, and elsewhere as indicated.
 - E. Install airtight access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter. Duct access panels shall be adequately sized to provide access to all fire and/or smoke damper fusible links.
 - F. All electrical connections to smoke damper actuators and smoke detectors (duct or ceiling mounted) shall be provided by the ATC contractor.
 - G. Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.

3.3 DUCT CLEANING

- A. Clean and sanitize all existing to remain ductwork, terminal units and air devices associated with systems renovated / modified under this project.
- B. Prior to cleaning or sanitizing ductwork/equipment, all equipment utilized to perform those processes shall be sanitized. Examine ductwork/equipment prior to performing work and provide new duct openings where required to provide visual inspection of the duct interior.
- C. Unless indicated otherwise, the systems shall be cleaned and sanitized in the following order:
 1. Exhaust systems
 2. Return systems
 3. Air handling unit(s)
 4. Air handling unit supply systems
- D. Duct cleaning of the above systems listed shall include air devices, terminal reheat units, etc.
- E. Cleaning Process:

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1. General:
 - a. Systems shall be de-energized while duct cleaning and sanitizing are in progress.
 - b. HEPA filter vacuums shall be used to keep room air clean. Ceiling tile shall be handled with care, and repaired or replaced as required to restore to the original condition.
2. Air Handler Cleaning Procedures:
 - a. Vacuum completely, beginning with the area upstream of the filters. Filters shall be replaced at the completion of the work.
 - b. Vacuum the fan and fan chamber.
 - c. Wash/degrease fan blades as required.
 - d. Wash/degrease chamber upstream of the coils as required.
 - e. Clean coils.
 - f. Sanitize.
3. Coil Cleaning Procedure: The procedure shall be customized to the situation encountered. The most heavily soiled coils may take a more complicated procedure of solution/pressure spraying. Most require only low pressure application of special cleaning solution and rinsing after they are first fully vacuumed.
4. Furniture Coverage from Incidental Dirt: As required, drape surrounding instruments, computers and areas with plastic to protect them from any incidental dirt generated during the cleaning process. Work environment shall be clean at all times. Floor shall be vacuumed as needed.
5. Duct Cleaning: Cleaning shall be accomplished by mechanical means in conjunction with the use of High CFM HEPA style vacuums and three (3) filtered canister vacuums. Mechanical means may include vacuum brushing of the duct interior, auger style mechanical devices, or high pressure air activated in duct cleaning devices to scrape off any dirt adhered to duct walls. Cleaning may be accomplished by a combination of these methods. Where possible, clean a full run or section before beginning another to insure full cleaning coverage. All material in the vacuum shall be disposed of daily after being treated with a sanitizer.
6. Sanitizing Process: Sanitizing shall be accomplished in two stages. First, it shall be done as each section of the air system is cleaned. The sanitization process shall be repeated again after the complete system has been cleaned. All sanitizing

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shall be completed before access is sealed. Diffusers shall be cleaned and sanitized. EPA recognized/registered sanitizers only shall be used. MSDS information shall be supplied for materials selected. Sanitizers/encapsulants shall not be used as a substitute for proper cleaning.

7. Clean Tests: Tests for bacteria/fungi shall be performed after all cleaning and sanitizing is completed to insure the clean standards have been met. This shall be done while the system is in operation and shall be a minimum of forty-eight (48) hours after the last sanitation has been completed.
8. Closing and Sealing: Provide galvanized sheet metal plate(s) to be used as access for the majority of locations. Square cut 22 gauge metal shall be used with each plate to lap its edges by one inch all around. Screws shall be placed at four inch (100 mm) intervals and the plate shall be sealed with a water-based fireproof sealant to ensure proper seal of the system to match existing pressure classification.
9. Encapsulation: There may be times when it is necessary to use an encapsulant on interior lined duct. It should be used only if circumstances require it (for example, the lining may be breaking down), and shall be agreed to in advance by the client. It shall not be used as a substitute for cleaning.
10. Duct cleaning shall be performed by Applied Building Technologies, Inc. or equivalent.

3.4 FIELD QUALITY CONTROL

- A. Operate installed duct accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.

3.5 ADJUSTING AND CLEANING

- A. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper operation.
 1. Final positioning of manual dampers is specified in Division-23 section "Testing, Adjusting and Balancing."
- B. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
- C. Provide MERV 13 filter media at all return air inlet locations throughout the duration of construction. Filter media shall not be removed until final filters are installed in the air handling units.

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3.6 EXTRA STOCK

- A. Furnish extra fusible links to the Owner; one (1) link for every ten (10) installed of each temperature range.

END OF SECTION 233300

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SECTION 233423 - POWER AND GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of power and gravity ventilator work required by this section is indicated on drawings and schedules, and by requirements of this section and all other Division-23 sections.
- B. Types of power and gravity ventilators specified in this section include the following:
 - 1. Power ventilators:
 - a. Centrifugal roof ventilators
 - 2. Prefabricated roof curbs
- C. Refer to Division-7 sections for installation of prefabricated roof curbs; not work of this section.
- D. Refer to requirements of Division-26.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of power and gravity ventilators, of types and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Codes and Standards:
 - 1. AMCA Compliance: Provide power ventilators which have been tested and rated in accordance with AMCA standards, and bear AMCA Certified Ratings Seal for air and sound performance.
 - 2. UL Compliance: Provide power ventilators which are listed by UL and have UL label affixed.
 - 3. NEMA Compliance: Provide motors and electrical accessories complying with NEMA standards.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical data for power and gravity ventilators, including specifications, capacity ratings, dimensions, weights, materials, accessories furnished, and installation instructions.

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- B. Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, construction details, methods of assembly of components, and field connection details.
- C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to power ventilators. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of that are factory-installed and portions to be field-installed.
- D. Maintenance Data: Submit maintenance data and parts list for each type of power and gravity ventilator, accessory, and control. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual.

PART 2 - PRODUCTS

2.1 POWER VENTILATORS

- A. General: Except as otherwise indicated, provide standard prefabricated power ventilator units of type and size indicated, modified as necessary to comply with requirements, and as required for complete installation.
- B. Centrifugal Roof Ventilators:
 1. Provide centrifugal roof type, curb mounted, power ventilators of type, size, and capacity as scheduled, and as specified herein.
 2. Type: Centrifugal fan, direct or belt driven as scheduled. Provide one-piece heavy gauge, spun aluminum housing. Provide square base to suit roof curb. Provide belt driven fans unless otherwise indicated.
 - a. Housing Design: Hooded dome type.
 3. Fans shall be statically and dynamically balanced.
 4. Motor and fan assembly shall be on vibration isolating mounts.
 5. Bird Screens: Provide removable bird screens, 1/2" (13 mm) mesh, 16-gauge (1.6 mm) aluminum or brass wire.
 6. Dampers: Provide louvered motor operated dampers with linkage in curb base.
 7. Fans and prefabricated roof curbs, where required, shall be the product of the same manufacturer.
 8. Electrical: Provide factory-wired non-fusible type disconnect switch at motor in fan housing. Provide thermal overload protection in fan motor. Provide conduit chase within unit for electrical connection.
 9. Refer to Division-23 Automatic Control Systems sections for damper motor and control sequence; not work of this section.

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2.2 PREFABRICATED ROOF CURBS

- A. General: Provide manufacturer's standard shop-fabricated units, modified if necessary to comply with requirements. Provide prefabricated roof curbs for each roof mounted fan and/or intake/relief device previously specified, and shall be the product of the manufacturer.
- B. Fabricate structural framing for units of structural quality sheet steel (ASTM A 570, Grade 40), formed to profiles indicated or, if not indicated, to manufacturer's standard profiles for coordination with roofing, insulation and deck construction. Include 45 cant strips and deck flanges with offsets to accommodate roof insulation. Weld corners and seams to form watertight units.
 - 1. Fabricate units from zinc-coated steel, ASTM A 446, Grade C, designation G90 hot-dip coating, mill phosphatized. Clean and paint with rust-inhibitive metal primer paint, of type recommended by manufacturer, 2.0 mils dry film thickness.
- C. Reinforce continuous runs of over 3'-0" (900 mm - 0 mm) length by inserting welded stiffeners of heavy gauge with flanges as required to provide sufficient rigidity and strength to withstand maximum lateral forces in addition to superimposed vertical loads.
- D. Sloping Roof Decks: For deck slopes of 1/4 per foot (20 mm/m) and more, fabricate support units to form level top edge.
- E. Gage and Height: Fabricate units of metal gauge and to height above roof surface as indicated.
 - 1. Where gage or height is not indicated, fabricate units of 18-gauge metal, and minimum height of 12" (300 mm).
- F. Provide treated wood nailing, not less than 1-5/8" (40 mm) thick and of width indicated, but not less than width of support wall assembly. Anchor nailing securely to top of metal frame unit.
- G. Provide lumber pressure treated with water-borne preservatives for "above ground" use, complying with AWPB LP-2.
- H. Insulate units inside structural support wall with rigid glass fiber insulation board of approximately 3-lb. density (21 kPa) and 1-1/2" (40 mm) minimum thickness, except as otherwise indicated.
- I. Provide support liners where shown, formed of 22-gauge (.85 mm) galvanized sheet metal, mill phosphatized, flanged at lower edges.
 - 1. Extend support liners through deck construction to coordinate with ductwork below as indicated.
 - 2. Use perforated metal for support liners, with approximately 1000, 3/32" (2 mm) diameter holes per sq. ft. (m²), to provide sound absorbing surfaces.

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- a. Provide sound insulation insert for curbs so indicated. Construct of 1" (25 mm) thick rigid fiberglass panels secured in galvanized steel framework, with rounded edges to minimize air flow resistance.
- J. Provide burglar-proof grille in curb units for roof openings of more than 1'- 0" (300 mm - 0 mm) width. Fabricate grille of 3/4" (120 mm) diameter hardened steel bars, spaced 6" o.c. (150 mm) in one direction and 12" o.c. (300 mm) in other direction. Weld ends of bars to curb walls, and weld bars at intersections. Clean and paint with rust-inhibitive metal primer.
- K. Metal Deck Reinforcement: Where indicated as integral part of support units, provide channel-shaped metal deck closure strips to reinforce opening through metal decking. Fabricate strips from 14-gauge (2 mm) metal to match metal and finish of curb units, except as otherwise indicated.

PART 3 - EXECUTION

3.1 INSPECTION

- A. General: Examine areas and conditions under which power and gravity ventilators are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF POWER AND GRAVITY VENTILATORS

- A. General: Except as otherwise indicated or specified, install ventilators in accordance with manufacturer's installation instructions and recognized industry practices to insure that ventilators serve their intended function.
- B. Coordinate ventilator work with work of roofing, walls, and ceilings, as necessary for proper interfacing.
- C. Ductwork: Refer to Division-23 ductwork sections. Connect ducts to ventilators in accordance with manufacturer's installation instructions.
 - 1. Provide access door in duct below ventilator to service damper.
 - 2. Solder bottom joints and up 2" (50 mm) of side joints of duct under roof ventilator to retain any moisture entering ventilator.
- D. Roof Curbs: Furnish roof curbs to roofing Installer for installation.
- E. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to electrical installer.
 - 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections. Verify proper

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rotation direction of fan wheels. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

- F. Remove shipping bolts and temporary supports within ventilators. Adjust dampers for free operation.
- G. Fans and associated roof curbs and ductwork serving kitchen exhaust hoods shall comply with NFPA 96 "Vapor Removal from Commercial Cooking Equipment" requirements.

END OF SECTION 233423

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SECTION 233600 - AIR TERMINALS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of air terminals work required by this section is indicated on drawings and schedules, and by requirements of this section.
- B. Types of air terminals specified in this section include the following:
 - 1. Air Terminals
 - a. Single Duct Variable Air Volume (VAV)
- C. Refer to requirements of Division-26.

1.2 QUALITY ASSURANCE

- A. Codes and Standards:
 - 1. ARI Compliance: Provide air terminals which have been tested and rated in accordance with the most current version of ARI Standard 880 "Industry Standard for Air Terminals" and bear ARI certification seal. Sound level adjustment factors shall be based on the most current version of ARI Standard 885. Coils shall be ARI 410 rated and certified.
 - 2. NFPA Compliance: Construct air terminals using acoustical and thermal insulations complying with NFPA 90A "Air Conditioning and Ventilating Systems".

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including performance data for each air terminal furnished; schedule showing drawing designation, room location, number furnished, model number, size, Noise Criteria (NC) levels for discharge and radiated sound, static pressure loss, and accessories furnished. Also, provide installation and start-up instructions.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.
- C. Wiring Diagrams: Submit ladder-type wiring diagrams for electric power and control components, clearly indicating required field electrical connections.
- D. Maintenance Data: Submit maintenance data and parts list for each type of air terminal; including "trouble-shooting" maintenance guide. Include this data, product

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data, shop drawings, and maintenance data in maintenance manual.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Deliver air terminals wrapped in factory-fabricated fiberboard type containers. Identify on outside of container type of air terminal and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in boxes.
- B. Store air terminals in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work shall be limited to the following:
 - 1. Titus
 - 2. Krueger
 - 3. Price
 - 4. Nailor
 - 5. Anemostat
 - 6. ETI

2.2 SUPPLY AIR TERMINALS

- A. General: Provide factory-fabricated and tested air terminals as indicated, selected with performance characteristics which match or exceed those indicated on schedule.
- B. Casing/Insulation: Unit casing shall be 22 (.8 mm) gauge galvanized steel, internally insulated. Insulation shall be as follows:
 - 1. Insulation shall be 1" (25 mm), 1-1/2 pound density (10 kPa) fiberglass insulation which complies with UL 181 and NFPA 90A. All exposed insulation edges shall be coated with an NFPA 90A approved sealant to prevent erosion. Fiberglass insulation shall contain an EPA registered antimicrobial agent which resists the growth of bacteria and fungi as proven by tests in accordance with ASTM G21 and G22.
- C. Leakage: Construct casings and dampers such that when subjected to 3.0-in w.g. (747 Pa) pressure, total leakage does not exceed maximum values indicated below. Casing

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leakage rate shall include leakage from the entire terminal unit assembly from inlet connection through a factory mounted reheat coil (where applicable).

<u>Inlet Size</u>	<u>Casing Leakage</u>	<u>Damper Leakage</u>
5, 6	4 cfm (1.9 L/s)	5 cfm (2 L/s)
8	6 cfm (2.8 L/s)	5 cfm (2 L/s)
10	8 cfm (3.8 L/s)	5 cfm (2 L/s)
12	9 cfm (4.3 L/s)	5 cfm (2 L/s)

- D. Air Dampers: Construct of non-corrosive heavy gauge metal with shaft rotating on self-lubricating bearings. Provide mechanism to vary air volume from minimum to maximum in response from signal from thermostat.
- E. Provide a factory mounted control enclosure.
- F. Provide an access panel in bottom of air terminal.
- G. Controls: Unit controls shall reset supply air volume to within 5% of design air flow regardless of system pressure.
 - 1. Temperature control contractor shall provide direct digital controllers (DDC) as specified in other Division-23 sections. DDC controllers shall be shipped from the ATC contractor to the air terminal manufacturer for factory installation by the air terminal manufacturer.
 - 2. Units shall have pressure independent control. Air flow limiters will not be accepted.
- H. Identification: Provide label on each unit indicating size designation, CFM range and CFM factory-setting.
- I. Sound: The manufacturer shall furnish certified sound power levels, and associated Noise Criteria (NC) levels, for both discharge and radiated sound, tested in accordance with the most current ASHRAE standards and ARI standard 880. The tests shall be conducted in an ARI-ADC approved sound facility. The following sound adjustment factors shall be utilized for each terminal unit to determine resulting sound levels within the occupied spaces:

<u>dB reduction (2nd thru 7th octave bands)</u>							
	2	3	4	5	6	7	
Discharge: 5" inlet	16	12	9	7	8	9	
6" inlet and above	18	13	11	10	11	12	

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Radiated: 5" inlet and above 17 18 19 25 30 33

The above attenuation values include environmental adjustment factor, branch power division, end reflection, space effect, ceiling tile loss, etc. Additional attenuation factors shall not be used and will not be acceptable. Where lined (fiberglass) ductwork is indicated on the drawings, attenuation reduction values indicated in the most current version of ARI standard 885 can be utilized up to a maximum of five (5) feet of lined ductwork.

Maximum Noise Criteria (NC) levels, indicated on the mechanical drawings, shall not be exceeded in the 2nd thru 7th octave bands at the design inlet static pressure indicated on the schedule (typically 1.5 in. w.c.). Where required, provide sound attenuators for discharge noise control, and/or GWB backed acoustical ceiling tile (gypsum wall board with 3-1/2" batt insulation attached to ceiling tile) for a radius of 15 feet from the VAV terminal for radiated noise control, to obtain Noise Criteria (NC) levels indicated on the drawings. Sound attenuator shall be manufactured such that fiberglass is not exposed to the airstream.

- J. Hot Water Reheat Coils: Provide heating coils constructed of copper tubes and aluminum fins. Coils shall be internally mounted in the casing at the factory. Heating coils shall be by terminal unit manufacturer. Unless specifically indicated otherwise, provide minimum 2-row coils for all air terminals.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which air terminals are to be installed. Do not proceed with work until satisfactory conditions have been corrected.

3.2 INSTALLATION OF AIR TERMINALS

- A. General: Install air terminals as indicated, and in accordance with manufacturer's installation instructions.
- B. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.
- C. Code Clearance: The installation shall provide adequate clearances in accordance with the latest edition of the National Electrical Code (NEC) for all components (DDC controllers, electric coil accessories, etc.) associated with the air terminal units.
- D. Duct Connections: The sheet metal contractor shall provide a minimum of three (3) duct diameters, but not less than three feet (3'), of straight, rigid duct upstream of the terminal unit inlet.

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- E. Insulation: The Contractor shall insulate all external portions of the coil and /or coil section to prevent condensation.

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation and prior to initial operation, test and demonstrate that air terminals and duct connections to air terminals are leak-tight.
- B. Repair or replace air terminals and duct connections as required to eliminate leaks, and retest to demonstrate compliance.

3.4 CLEANING

- A. Clean exposed factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION 233600

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SECTION 233700 - AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-01 Specification sections, apply to work of this section.

1.2 DESCRIPTION OF WORK

- A. Extent of air outlets and inlets work is indicated by drawings and schedules, and by requirements of this section and all other Division-23 sections.
- B. Types of air outlets and inlets required for project include the following:
 - 1. Ceiling air diffusers
 - 2. Registers and grilles

1.3 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air outlets and inlets of types and capacities required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Codes and Standards:
 - 1. ARI Compliance: Test and rate air outlets and inlets in accordance with ARI 650 "Standard for Air Outlets and Inlets".
 - 2. ASHRAE Compliance: Test and rate air outlets and inlets in accordance with ASHRAE 70 "Method of Testing for Rating the Air Flow Performance of Outlets and Inlets".
 - 3. ADC Compliance: Test and rate air outlets and inlets in certified laboratories under requirements of ADC 1062 "Certification, Rating and Test Manual".
 - 4. ADC Seal: Provide air outlets and inlets bearing ADC Certified Rating Seal.
 - 5. NFPA Compliance: Install air outlets and inlets in accordance with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data for air outlets and inlets

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including the following:

1. Schedule of air outlets and inlets indicating drawing designation, room location, number furnished, model number, size, Noise Criteria (NC) levels, static pressure loss, and accessories furnished.
 2. Data sheet for each type of air outlet and inlet, and accessory furnished; indicating construction, finish, and mounting details.
 3. Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses, throw and drop, and noise criteria ratings. Indicate selections on data.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawing for each type of air outlet and inlet, indicating materials and methods of assembly of components.
- C. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver air outlets and inlets wrapped in factory-fabricated fiber-board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.
- B. Store air outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work shall be limited to the following:
1. Titus
 2. Krueger
 3. Price
 4. Nailor
 5. Anemostat
 6. Metal Air

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2.2 CEILING AIR DIFFUSERS

- A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
- B. Performance: Provide ceiling air diffusers that have, as a minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.
- C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.
- D. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as listed on diffuser schedule. The following requirements shall apply to nomenclature indicated on schedule:
- E. Diffuser Materials:
 - 1. Steel Construction: Manufacturer's standard stamped sheet steel frame and adjustable blades.
 - 2. Aluminum Construction: Manufacturer's standard extruded aluminum frame and adjustable blades.
- F. Diffuser Faces:
 - 1. Square: Square housing, core of square concentric louvers, square or round duct connection. (See drawings).
 - 2. Linear: Extruded aluminum continuous slot, single or multiple.
- G. Diffuser Mountings:
 - 1. Flush: Diffuser housing above ceiling surface with flush perimeter flange and gasket to seal against ceiling.
 - 2. Lay-In: Diffuser housing sized to fit between ceiling exposed suspension tee bars and rest on top surface of tee bar.
- H. Diffuser Patterns:
 - 1. 4-Way: Fixed louver face for 4-direction air flow, directions indicated on drawings.
- I. Diffuser Dampers:
 - 1. Fire Damper: Where indicated, provide combination adjustable opposed blade damper and fusible link fire damper with UL approved link and assembly designed

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to meet requirements of NFPA 90A.

J. Diffuser Finishes:

1. Aluminum Enamel: Air-dried aluminum enamel prime finish.
2. White Enamel: Semi-gloss white enamel prime finish.
3. Aluminum Anodize: Aluminum etched and anodized, covered with clear lacquer finish.

2.3 REGISTERS AND GRILLES

- A. General: Except as otherwise indicated, provide manufacturer's standard registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
- B. Performance: Provide registers and grilles that have, as a minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.
- C. Surface Compatibility: Provide registers and grilles with border styles that are compatible with adjacent surfaces, and that are specifically manufactured to fit with accurate fit and adequate support. Refer to general construction drawings and specifications for types of construction which will contain each type of register and grille.
- D. Types: Provide registers and grilles of type, capacity, and with accessories and finishes as listed on register and grille schedule. The following requirements shall apply to nomenclature indicated on schedule:
 1. Register and Grille Materials:
 - a. Steel Construction: Manufacturer's standard stamped sheet steel frame and adjustable blades.
 - b. Aluminum Construction: Manufacturer's standard extruded aluminum frame and adjustable blades.
 2. Register and Grille Faces:
 - a. Horizontal Fixed Blades: Horizontal blades, fixed at 35 degrees, with 3/4" (20 mm) spacing. Blades shall be parallel to long dimension.
 3. Register and Grille Patterns:
 - a. Single Deflection: 1-set of blades in face.
 4. Register and Grille Finishes:
 - a. Aluminum Enamel: Air-dried aluminum enamel prime finish.

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- b. White Enamel: Semi-gloss white enamel prime finish.
- c. Aluminum Anodize: Aluminum etched and anodized, covered with clear lacquer finish.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which air outlets and inlets are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. General: Install air outlets and inlets in accordance with manufacturer's written instructions. Air outlets and inlets shall be independently supported from the structure at two (2) locations and in accordance with recognized industry practices to insure that products serve intended functions. The ceiling or ceiling grid shall not be considered as a means of support.
- B. Coordinate with other work, including ductwork and duct accessories, as necessary to interface installation of air outlets and inlets with other work.
- C. Locate ceiling air diffusers, registers, and grilles, as indicated on general construction "Reflected Ceiling Plans". Unless otherwise indicated, locate units in center of acoustical ceiling modules.
- D. Provide MERV 13 filter media at all return air inlet locations throughout the duration of construction. Filter media shall not be removed until final filters are installed in the air handling units.

END OF SECTION 233700

SECTION 237313 - AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Scope: Extent of air handling unit work required by this Section is indicated on the drawings, by requirements of this Section, and all other Division-23 Sections.
- B. Refer to requirements of Division-26.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Provide air handling units that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.
- B. Certifications: Provide certified ratings of units based on tests performed in accordance with ARI 430.
- C. Codes and Standards: Provide air handling units conforming to the following:
 1. Air Movement and Control Association, Inc. (AMCA): Comply with applicable AMCA including:
 - a. 210 Laboratory Methods of Testing Fans for Rating Purposes
 - b. 500 Test Method for Louvers, Dampers, and Shutters
 2. Air-Conditioning and Refrigeration Institute (ARI): Comply with applicable ARI including the following:
 - a. 410 Forced-Circulation Air-Cooling and Air-Heating Coils
 - b. 430 Central-Station Air-Handling Units
 3. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE): Construct and install refrigerant coils in accordance with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
 4. National Electrical Manufacturers Association (NEMA): Except for motors, provide electrical components required as part of air handling units, which comply with NEMA Standards.
 5. National Fire Protection Association (NFPA): Provide air handling unit internal insulation having flame spread rating not over 25 and smoke developed rating no higher than 50; and complying with NFPA 90A, "Standard for the Installation of

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Air Conditioning and Ventilating Systems." Comply with NFPA 70, "National Electrical Code," as applicable for installation and electrical connections of ancillary electrical components of air handling units.

6. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Comply with applicable SMACNA standards including "HVAC Duct Construction Standards - Metal and Flexible."
7. Underwriters Laboratories, Inc. (UL): Except for motors, provide electrical components required as part of air handling units, which have been listed and labeled by UL.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data for air handling units showing dimensions, weights, capacities, ratings, fan performance with operating point clearly indicated, motor electrical characteristics, and finishes of materials, and installation instructions.
- B. Shop Drawings: Submit shop drawings showing unit dimensions, weight loadings, required clearances, field connection details and methods of support. Draw to a scale of one half inch to one foot (13 mm to 300 mm), using same sheet size as Contract Drawings. Include field fabricated mixing boxes, dampers and duct connections.
- C. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Delivery: Deliver air handling units with factory-installed shipping skids and lifting lugs; pack small components in factory-fabricated protective containers.
- B. Handling: Handle air handling units carefully to avoid damage to components, enclosures, and finish. Do not install damaged components; replace and return damaged components to air handling unit manufacturer.
- C. Storage: Store air handling units in clean dry place and protect from weather and construction traffic.
- D. Unloading: Comply with manufacturer's rigging and installation instructions for unloading air handling units, and moving them to final locations.

PART 2 - PRODUCTS

2.1 AIR HANDLING UNITS (AHU-1, 7 & 9)

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work, shall be limited to the following:
 - 1. Daikin
 - 2. Annex Air
 - 3. Aaon
- B. General:
 - 1. Certify capacity, static pressure, fan speed, brake horsepower and selection procedures in accordance with ARI 430-89.
 - 2. Furnish and install air handling units as shown and scheduled on the plans. The units shall be installed in strict accordance with the specifications.
- C. Unit Construction:
 - 1. Fabricate unit with heavy gauge channel posts and panels secured with mechanical fasteners. All panels, access doors, and ship sections shall be sealed with permanently applied bulb-type gasket. Shipped loose gasketing is not allowed.
 - 2. Panels and access doors shall be constructed as a 2-inch nominal thick; thermal broke double wall assembly, injected with foam insulation with an R-value of not less than R-13.
 - a. The inner liner shall be constructed of G90 galvanized steel.
 - b. The outer panel shall be constructed of G90 galvanized steel.
 - c. The floor plate shall be constructed as specified for the inner liner.
 - d. Unit will be furnished with solid inner liners.
 - 3. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, maximum 5 inches of positive or 6 inches of negative static pressure. Deflection shall be measured at the panel midpoint.
 - 4. The casing leakage rate shall not exceed 0.50 cfm per square foot of casing surface area at design static pressure up to a maximum of +5" w.c. in positive pressure sections and -6" w.c. in negative pressure sections (.0025 m³/s per square meter of cabinet area at 1.24 kPa static pressure)

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5. Module to module field assembly shall be accomplished with an overlapping, full perimeter internal splice joint that is sealed with bulb type gasketing on both mating modules to minimize on-site labor and meet indoor air quality standards.
6. Access doors shall be flush mounted to cabinetry, with minimum of two six inch long stainless steel piano-type hinges, latch and full size handle assembly. Access doors shall swing outward for unit sections under negative pressure. Access doors on positive pressure sections, shall have a secondary latch to relieve pressure and prevent injury upon access.
7. A 6-inch formed G60 galvanized steel base rail shall be provided by the unit manufacturer for structural rigidity and condensate trapping. The base rail shall be constructed with 12-gauge nominal. Coordinate rail height with condensate drain requirement.
8. Construct drain pans from stainless steel with cross break and double sloping pitch to drain connection. Provide drain pans under cooling coil section. Drain connection centerline shall be a minimum of 3" above the base rail to aid in proper condensate trapping. Drain connections that protrude from the base rail are not acceptable. There must be a full 2" thickness of insulation under drain pan.

D. Fan Assemblies:

1. Fan assembly shall be a single width, single inlet, class II, direct-drive type plenum fan dynamically balanced as an assembly, as shown in schedule. Maximum fan RPM shall be below first critical fan speed. Fan assemblies shall be dynamically balanced by the manufacturer on all three planes. Provide access to motor and fan assembly through hinged access door.
2. Fan and motor shall be mounted internally on a steel base. Factory mount motor on slide base that can be slid out the side of the unit if removal is required. Provide access to motor, drive, and bearings through hinged access door. Fan and motor assembly shall be mounted on 2" deflection spring vibration type isolators inside cabinetry.

E. Bearings, Shafts, And Drives:

1. Bearings: Basic load rating computed in accordance with AFBMA - ANSI Standards. The bearings shall be provided on the motor with the fan wheel mounted directly on the motor shaft, AMCA arrangement 4.
2. Shafts shall be solid, hot rolled steel, ground and polished, keyed to shaft, and protectively coated with lubricating oil. Hollow shafts are not acceptable.
3. The fan wheel shall be direct coupled to the motor shaft. The wheel width shall be determined by motor speed and fan performance characteristics.

F. Electrical:

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1. Fan motors shall be manufacturer provided and installed, Open Drip Proof, premium efficiency (meets or exceeds EPAct requirements), 3500 RPM, single speed, 460V / 60HZ / 3P. Complete electrical characteristics for each fan motor shall be as shown in schedule.
2. Wiring Termination: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclosed terminal lugs in terminal box sized to NFPA 70.
3. Air handler manufacturer shall provide, mount and wire variable speed drive with electrical characteristics such as indicated on project schedule and shown on manufacturer's data sheets.

G. Cooling and Heating Coils:

1. Water cooling coil shall be provided. Provide access to coil(s) for service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 5" beyond unit casing for ease of installation. Drain and vent connections shall be provided exterior to unit casing. Coil connections must be factory sealed with grommets on interior and exterior panel liners to minimize air leakage and condensation inside panel assembly. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.
 - a. Headers shall consist of seamless copper tubing to assure compatibility with primary surface. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.
 - b. Fins shall have a minimum thickness of 0.0075 inch aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.
 - c. Coil tubes shall be 5/8 inch OD seamless copper, 0.020 inch nominal tube wall thickness, expanded into fins, brazed at joints.
 - d. Coil connections shall be carbon steel, NPT threaded connection. Connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain fittings shall be furnished on the connections, exterior to the air handler. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point to insure complete drainage and prevent freeze-up.
 - e. Coil casing shall be a formed channel frame of galvanized steel.
2. Water heating coil shall be provided. Provide access to coil(s) for service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit

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shall be provided with coil connections that extend a minimum of 5" beyond unit casing for ease of installation. Drain and vent connections shall be provided exterior to unit casing. Coil connections must be factory sealed with grommets on interior and exterior panel liners to minimize air leakage and condensation inside panel assembly. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.

- a. Headers shall consist of seamless copper tubing to assure compatibility with primary surface. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.
- b. Fins shall have a minimum thickness of 0.0075 inch aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.
- c. Coil tubes shall be 5/8 inch OD seamless copper, 0.020 inch nominal tube wall thickness, expanded into fins, brazed at joints.
- d. Coil connections shall be carbon steel, threaded connection. Connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain fittings shall be furnished on the connections, exterior to the air handler. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point to insure complete drainage and prevent freeze-up.
- e. Coil shall be furnished as an uncased galvanized steel to allow for thermal movement and slide into a pitched track for fluid drainage.

H. Filters:

1. Furnish combination filter section with 2-inch pleated MERV 8 flat pre-filter and 4-inch cartridge MERV 13 final filter. Provide side loading and removal of filters.
2. Filter media shall be UL 900 listed, Class I or Class II.
3. Filter Magnehelic gauge(s) shall be furnished and mounted by equipment manufacturer.

I. ADDITIONAL SECTIONS

1. Plenum section shall be provided and properly sized for inlet and/or discharge air flow (between 600 and 1500 feet per minute). The plenum shall provide single or multiple openings as shown on drawings and project schedule.
2. Mixing box section shall be provided with openings as described on drawings. Dampers shall be hollow core galvanized steel airfoil blades, fully gasketed and

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have continuous vinyl seals between damper blades in a galvanized steel frame. Dampers shall have stainless steel jamb seals along end of dampers. Connecting linkage and ABS plastic end caps shall be provided when return and outside air dampers are each sized for full airflow. Return and outside air dampers of different sizes must be driven separately. Damper Leakage: Leakage rate shall be less than two tenths of one percent leakage at 2 inches static pressure differential. Leakage rate tested in accordance with AMCA Standard 500.

2.2 PACKAGED ROOFTOP UNITS (RTU-21, 22, 23, 24 & 25)

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work, shall be limited to the following:
 - 1. Daikin
 - 2. Annex Air
 - 3. Aaon
- B. General:
 - 1. Each unit shall be specifically designed for outdoor rooftop application and include a weatherproof cabinet. Each unit shall be completely factory assembled and shipped in one piece. Packaged units shall be shipped fully charged with R-410 Refrigerant and oil.
- C. Cabinet, Casing, and Frame:
 - 1. Panel construction shall be double-wall construction for all panels. All floor panels shall have a solid galvanized steel inner liner on the air stream side of the unit to protect insulation during service and maintenance. Insulation shall be a minimum of 2" thick with an R-value of 13.0, and shall be 2 part injected foam. Panel design shall include no exposed insulation edges. Unit cabinet shall be designed to operate at total static pressures up to 5.0 inches w.g.
 - 3. Exterior surfaces shall be constructed of pre-painted galvanized steel for aesthetics and long term durability. Paint finish to include a base primer with a high quality, polyester resin topcoat of a neutral beige color. Finished panel surfaces to withstand a minimum 1000-hour salt spray test in accordance with ASTM B117 standard for salt spray resistance.
 - 4. Service doors shall be provided on the fan section, filter section, control panel section, and heating vestibule in order to provide user access to unit components. All service access doors shall be mounted on multiple, stainless steel hinges and shall be secured by a latch system. Removable service panels secured by multiple mechanical fasteners are not acceptable. The fan section shall have a safety switch to de-energize fan when door is open.

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5. The unit base shall overhang the roof curb for positive water runoff and shall seat on the roof curb gasket to provide a positive, weathertight seal. Lifting brackets shall be provided on the unit base to accept cable or chain hooks for rigging the equipment.D. Outdoor/Return Air Section:
 1. Unit shall be provided with an outdoor air economizer section. The economizer section shall include outdoor, return, and exhaust air dampers. The economizer operation shall be fully integral to the mechanical cooling and allow up to 100% of mechanical cooling if needed to maintain the cooling discharge air temperature. The outdoor air hood shall be factory installed and constructed from galvanized steel finished with the same durable paint finish as the main unit. The hood shall include moisture eliminator filters to drain water away from the entering air stream. The outside and return air dampers shall be sized to handle 100% of the supply air volume. The dampers shall be parallel blade design. Damper blades shall be gasketed with side seals to provide an air leakage rate of 1.5 cfm / square foot of damper area at 1" differential pressure in accordance with testing defined in AMCA 500. A barometric exhaust damper shall be provided to exhaust air out of the back of the unit. A bird screen shall be provided to prevent infiltration of rain and foreign materials. Exhaust damper blades shall be lined with vinyl gasketing on contact edges. Control of the dampers shall be by a factory installed direct coupled actuator. Damper actuator shall be of the modulating, spring return type. A comparative enthalpy control shall be provided to sense and compare enthalpy in both the outdoor and return air streams to determine if outdoor air is suitable for "free" cooling. If outdoor air is suitable for "free" cooling, the outdoor air dampers shall modulate in response to the unit's temperature control system.
 2. Provide factory installed and tested, outdoor air monitor that controls outdoor air +/- 15% accuracy.

E. Energy Recovery (RTU-23 Only):

1. The rooftop unit shall be provided with an AHRI certified rotary wheel air-to-air heat exchanger in a cassette frame complete with seals, drive motor and drive belt. The energy recovery wheel shall be an integral part of the rooftop unit with unitary construction and does not require field assembly. Bolt-on energy recovery units that require field assembly and section to section gasketing and sealing are not acceptable.
2. The wheel capacity, air pressure drop and effectiveness shall be AHRI certified per AHRI Standard 1060. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Heat Exchangers For Energy Recovery Ventilation Equipment.
3. The rooftop unit shall be designed with a track so the entire energy recovery wheel cassette can slide out from the rooftop unit to facilitate cleaning.
4. The unit shall have 2" Merv 7 filters for the outdoor air before the wheel to help keep the wheel clean and reduce maintenance. Filter access shall be by a hinged access door with 1/4 turn latches.

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5. The matrix design shall have channels to reduce cross contamination between the outdoor air and the exhaust air. The layers shall be effectively captured in aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belt(s) of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.
6. The total energy recovery wheel shall be coated with silica gel desiccant permanently bonded without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.
7. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning.
8. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel. Wheels shall be connected to the shaft by means of taper lock hubs.
9. The exhaust air fan shall be a direct drive SWSI plenum fan. The exhaust fan shall be sized for the airflow requirements per the construction schedule. A VFD shall be provided for the exhaust fan motor or the exhaust fan motor shall be an ECM motor. The rooftop unit shall have single point electrical power connection and shall be ETL listed.
10. The control of the energy recovery wheel shall be an integral part of the rooftop unit's DDC controller. The DDC controller shall have visibility of the outdoor air temperature, leaving wheel temperature, return air temperature, and exhaust air temperature. These temperatures shall be displayed at the rooftop units DDC controller LCD display. All of these temperatures shall be made available through the BACnet interface.
11. The rooftop unit with the energy recovery wheel shall incorporate the economizer operation. The energy recovery wheel shall have a bypass damper. When the unit is in the economizer mode of operation the energy recovery wheel shall stop and the bypass dampers shall be opened. The outdoor air shall be drawn through the bypass dampers to reduce the pressure drop of the outdoor airstream.
12. The rooftop unit DDC controller shall provide frost control for the energy recovery wheel. When a frost condition is encountered the unit controller shall stop the wheel. When in the frost control mode the wheel shall be jogged periodically and not be allowed to stay in the stationary position.

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F. Exhaust Fan (RTU-23 Only):

1. Exhaust fan shall be a single width, single inlet (SWSI) airfoil centrifugal fan. The fan wheel shall be Class II construction with aluminum fan blades that are continuously welded to the hub plate and end rim. The exhaust fan shall be a direct drive fan mounted to the motor shaft.
2. The fan motor shall be a totally enclosed EC motor that is speed controlled by the rooftop unit controller. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase.

G. Filters:

1. Unit shall be provided with a draw-through filter section. Unit shall be provided with MERV 8 prefilters and MERV 13 final filters.
2. Filter selections shall be provided with double welled hinged access doors.
3. Provide magnehelic filter gauges for filter bank, graduated to read for 0 to 3" wg.

H. Cooling Coil:

1. The indoor coil section shall be installed in a draw through configuration, upstream of the supply air fan. The coil section shall be complete with a factory piped cooling coil and a double sloped drain pan.
2. The direct expansion (DX) cooling coils shall be fabricated of seamless high efficiency copper tubing that is mechanically expanded into high efficiency aluminum plate fins. Coils shall be a multi-row, staggered tube design with a minimum of 3 rows. All cooling coils shall have an interlaced coil circuiting that keeps the full coil face active at all load conditions. All coils shall be factory leak tested with high pressure air under water.
3. The cooling coil shall have an electronic controlled expansion valve. The unit controller shall control the expansion valve to maintain liquid subcooling and the superheat of the refrigerant system.
4. The refrigerant suction lines shall be fully insulated from the expansion valve to the compressors.
5. The drain pan shall be stainless steel and positively sloped. The slope of the drain pan shall be in two directions and comply with ASHRAE Standard 62.1. The drain pan shall have a minimum slope of 1/8" per foot to provide positive draining. The drain pan shall extend beyond the leaving side of the coil. The drain pan shall have a threaded drain connection extending through the unit base.

I. Hot Gas Reheat (RTU-21 and 22 Only):

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1. Unit shall be equipped with a fully modulating hot gas reheat coil with hot gas coming from the unit condenser
 2. Hot gas reheat coil shall be a Micro Channel design. The aluminum tube shall be a micro channel design with high efficiency aluminum fins. Fins shall be brazed to the tubing for a direct bond. The capacity of the reheat coil shall allow for a 20°F temperature rise at all operating conditions.
 3. The modulating hot gas reheat systems shall allow for independent control of the cooling coil leaving air temperature and the reheat coil leaving air temperature. The cooling coil and reheat coil leaving air temperature setpoints shall be adjustable through the unit controller. During the dehumidification cycle the unit shall be capable of 100% of the cooling capacity. The hot gas reheat coil shall provide discharge temperature control within +/- 2°F.
 4. Each coil shall be factory leak tested with high-pressure air under water.
- J. Supply Fan:
1. Supply fan shall be a single width, single inlet (SWSI) airfoil centrifugal fan. The fan wheel shall be Class II construction with fan blades that are continuously welded to the hub plate and end rim. The supply fan shall be a direct drive fan mounted to the motor shaft.
 2. All fan assemblies shall employ solid steel fan shafts. Heavy-duty pillow block type, self-aligning, grease lubricated ball bearings shall be used. Bearings shall be sized to provide a L-50 life at 250,000 hours. The entire fan assembly shall be isolated from the fan bulkhead with a flexible collar and mounted on 1" spring isolators.
 3. All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance, prior to shipment.
 4. Supply fan and motor assembly combinations larger than 8 hp or 22" diameter shall be internally isolated on 1" deflection, spring isolators and include removable shipping tie downs.
 5. The fan motor shall be a totally enclosed EC motor that is speed controlled by the rooftop unit controller. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase. Motors shall be premium efficiency.
 6. The motor shall be T Frame and open drip proof. Overload protection and speed control is provided by the factory installed VFD and rooftop unit controller. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase. Motors shall be premium efficiency.
 7. The supply fan shall be capable of airflow modulation from 30% to 100% of the scheduled designed airflow. The fan shall not operate in a state of surge at any point within the modulation range.

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K. Heating Section:

1. A hot water heating coil shall be factory installed in the heat section. The hot water heat section shall be installed downstream of the supply air fan. A factory-tested diffuser shall be used in order to provide air distribution across the coil. The rooftop unit shall include a piping vestibule. The coil connection shall terminate in the vestibule. All coil connections shall be copper, steel connections shall not be allowed in order to prevent dielectrics and corrosion.
2. Coils shall be fabricated of seamless 3/8" diameter copper tubing that is mechanically expanded into high efficiency rippled and corrugated aluminum plate fins. All coil vents and drains shall be factory installed. Hot water coil shall be fully cased to allow for easy replacement.
3. The coil shall have freeze protection and shall be controlled by the unit DDC controller. With the detection of a freeze condition the heating coil valve shall be driven fully open. The unit controller shall indicate an alarm.
4. Coil shall be factory leak tested with high pressure air under water.

L. Condensing Section:

1. Outdoor coils shall be cast aluminum, micro-channel coils. Plate fins shall be protected and brazed between adjoining flat tubes such that they shall not extend outside the tubes. A sub-cooling coil shall be an integral part of the main outdoor air coil. Each outdoor air coil shall be factory leak tested with high-pressure air under water.
2. The condenser fan shall be low noise blade design. Fan blade design shall be a dynamic profile for low tip speed. Fan blade shall be of a composite material.
3. The unit shall have scroll compressors. One of the compressors shall be an inverter compressor providing proportional control. The unit controller shall control the speed of the compressor to maintain the discharge air temperature. The inverter compressor shall have a separate oil pump and low oil safety protection.
4. Pressure transducers shall be provided for the suction pressure and head pressure. Temperature sensor shall be provided for the suction temperature and the refrigerant discharge temperature of the compressors. All of the above devices shall be an input to the unit controller and the values be displayed at the unit controller.
5. Refrigerant circuit shall have a bypass valve between the suction and discharge refrigerant lines for low head pressure compressor starting and increased compressor reliability. When there is a call for mechanical cooling the bypass valve shall open to equalizing the suction and discharge pressures. When pressures are equalized the bypass valve shall close and the compressor shall be allowed to start.

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6. Each circuit shall be dehydrated and factory charged with R-410A Refrigerant and oil.

M. Electrical:

1. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical components provided with the unit shall be number and color-coded and labeled according to the electrical diagram provided for easy identification. The unit shall be provided with a factory wired weatherproof control panel. Unit shall have a single point power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch short circuit protection, 115-volt control circuit transformer and fuse, system switches, and a high temperature sensor shall also be provided with the unit. Each compressor and condenser fan motor shall be furnished with contactors and inherent thermal overload protection. Supply fan motors shall have contactors and external overload protection. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance.
2. An integral fused disconnect switch shall be provided for disconnecting electrical power at the unit. Disconnect switches shall be mounted internally to the control panel and operated by an externally mounted handle.
3. Units shall have an SCCR rating of 65 KAIC.

N. Controls:

1. Unit shall be provided with refrigeration circuit controls and shall communicate with BACnet ATC system.
2. Unit shall not be provided with any other unit controller or sensors. All ATC related components (other than refrigeration circuit control) shall be provided by ATC Contractor.

O. Curb:

1. Curb shall be provided by the unit manufacturer. Curbs shall be constructed of galvanized steel and have a wood nailing strip factory installed. Jointers, gasketing and bolts for assembly shall be provided as required. A pipe nipple for condensate drainage system shall be provided for each coil section. Curb design shall be such that the unit will be installed level and compensate for the significant roof slope. Provide curb by independent manufacturer if required to accommodate roof slope. See architectural drawings for roof slope conditions.

P. Provide a 120 volt GFI receptacle that is wired to a separate electric circuit.

2.3 MOTORS (TYPICAL FOR ALL AIR HANDLING UNITS)

- A. See Division-23 Section, "Electrical Provisions for HVAC Equipment" for minimum motor efficiencies and other requirements.

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2.4 ROOFTOP UNIT SOUND TREATMENT

- A. Provide the following field installed sound treatment within the roof curb for all rooftop air handling units:

1. The rooftop unit sound treatment system shall be installed on all curb mounted rooftop units (RTU). The system shall be an airborne noise isolation package for reducing radiated sound from the RTU down through the curb deck. The treatment shall be as manufactured by BRD Noise and Vibration Control, Inc., Wind Gap, PA, or equivalent. The system shall be supported by the roof deck structure within the curb. Overcut openings for the duct drops shall be flashed to maintain a gap no greater than $\frac{1}{4}$ ". There shall be no contact between the decking and the ducts. HUSH BATT™ model HB-200 shall be installed in a double layer on the bottom with a single layer of HUSH BLOCK™ model ABAC-121N composite sound insulation on top. The airborne noise insulation package shall have the following sound transmission loss acoustical performance.

Hz	125	250	500	1K	2K	4K
19	22	28	40	56	61	

2. A representative of the sound system manufacturer shall inspect the in-curb deck system work on site prior to lowering of the units and issue a letter of certification stating that the products have been properly installed and sealed around all ductwork and drops to eliminate air gaps which can compromise performance. The manufacturer's report shall include photographs and document acceptable installation.

PART 3 - EXECUTION

3.1 INSTALLATION OF AIR HANDLING UNITS

- A. General: Install air handling units where indicated on the drawings, in accordance with equipment manufacturer's published installation instructions.
- B. Access: Provide access space around air handling units for service as indicated on the drawings, but in no case less than that recommended by the manufacturer.
- C. Mounting: Mount air handling units with internal factory furnished isolators in accordance with manufacturer's instructions.
- D. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted.
1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections.

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- E. Piping Connections: Provide piping, valves, accessories, gauges, supports, and flexible connections as indicated on the drawings. Locate freezestats and trap air handling unit drain-pan connections according to manufacturer's recommendations.
- F. Duct Connections: Provide ductwork, accessories, and flexible connections as required.
- G. Extend condensate drain to nearest drain. Provide trap at drain pan at least 1" (25 mm) deeper than total supply fan pressure in inches of water column. For indoor units, provide a concrete pad of adequate height to allow for proper installation of condensate drain trap above floor.
- H. Provide MERV 13 filter media at all return air inlet locations throughout the duration of construction. Filter media shall not be removed until final MERV 13 filters are installed in the air handling units.

3.2 FUNCTIONAL PERFORMANCE TESTING AND VERIFICATION

- A. General: In addition to the tests required during and after installation of all mechanical systems, as well as any other formal commissioning requirements, the unit manufacturer shall perform functional performance tests to verify that all systems are designed, installed, calibrated and adjusted to perform as required in the Contract.
- B. Comply with all applicable specification sections including, but not be limited to, "Basic HVAC Requirements", "Testing, Adjusting and Balancing", "Automatic Temperature Controls" and "Commissioning", where applicable.
- C. Prior to functional performance testing, all indicating, recording and control devices shall be calibrated. A verification calibration report shall be provided with the final test report.
- D. Provide functional performance testing to verify proper operation of each control sequence associated with the unit indicated throughout the contract documents.
- E. Failure of Tests: Should any test, verification, or demonstration fail to meet the specification requirements, the component of the system causing the failure shall be repaired, replaced or readjusted. The failed test, verification, or demonstration shall then be repeated.
- F. A "Functional Performance Test Verification Form" is included at the end of Section 230900. This form (electronic version is available upon request) shall be completed for each air handling unit provided under this contract.
- G. Test Report: Upon satisfactory verification of calibration and functional performance tests, a copy of the final test results shall be bound in the operations and maintenance manual. The final report shall also include a full compliance statement, on company letterhead, indicating that all units are installed and functioning per the contract requirements including drawings, specifications, control sequences and accepted submittals.

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- H. The air handling unit installation shall not be considered complete until all functional performance verification forms, calibration reports and compliance statement have been submitted and reviewed. Submit in accordance with the submittal requirements indicated elsewhere in these specifications.

3.3 EXTRA STOCK

- A. Filters: Provide two (2) extra set of filters for each air handling unit including MERV 13 final filters. Install new filters at completion of air handling system work, and prior to testing, adjusting, and balancing work. Do not operate fans unless filters are in place.
- B. Belts: If belt driven fans are provided, contractor shall provide two (2) spare set of belts for each belt-driven air handling unit. Deliver to the Owner's representative and mark with the air handling unit's number.

END OF SECTION 230100

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SECTION 238119 - ENVIRONMENTAL CONTROL AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Scope: Extent of environmental control air conditioning unit work required by this Section is indicated on drawings and schedules, by requirements of this Section, and all other Division-23 Sections.
- B. Refer to requirements of Division-26.

1.2 QUALITY ASSURANCE

- A. Manufacturer: Provide environmental control air conditioning units that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be field fabricated.
- B. Certifications: Submit certified technical and test data indicating compliance with the capacities specified.
- C. Codes and Standards: Provide environmental control air conditioning units conforming to the following:
 1. Air-Conditioning and Refrigeration Institution (ARI): Comply with ARI 240.
 2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): Construct and install refrigerant coils in accordance with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
 3. National Electrical Manufacturers Association (NEMA): Provide electrical components required as part of environmental control air conditioning units, which comply with NEMA Standards.
 4. National Fire Protection Association (NFPA): Comply with NFPA 70, "National Electrical Code" as applicable to installation and electrical connections of ancillary electrical components of environmental control air conditioning units.
 5. Underwriters Laboratories, Inc. (UL): Provide electrical components required as part of environmental control air conditioning units, which have been listed and labeled by UL.
- D. Certifications: Submit certified technical and test data indicating compliance with the capacities specified.

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1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's product data for air conditioning units showing dimensions, weights, capacities, ratings, fan performance with operating point clearly indicated, motor electrical characteristics, finishes of materials, and installation instructions.
- B. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts list. Include this data, product data, shop drawings, and wiring diagrams in maintenance manuals in accordance with requirements of Division-01.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Delivery: Deliver environmental control air conditioning unit with factory-installed shipping skids and lifting lugs; pack components in factory-fabricated protective containers.
- B. Handling: Handle environmental control air conditioning units carefully to avoid damage to components, enclosures, and finish. Do not install damaged components. Replace damaged units with new units.
- C. Storage: Store environmental control air conditioning units in a clean, dry place and protect from weather and construction traffic.
- D. Unloading: Comply with manufacturer's rigging instructions for unloading air conditioning units and condensing units, and moving them to final location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work will be limited to:
 1. Daikin
 2. Mitsubishi
 3. Equal approved by engineer and owner

2.2 ENVIRONMENTAL CONTROL AIR CONDITIONING UNITS

- A. General: Provide factory assembled air conditioning system complete with split system compact wall mounted packaged evaporator section and matching outdoor unit. The units shall be listed by Electrical Laboratories (ETL) and bear the ETL label. All wiring shall be in accordance with the National Electrical Code (NEC). The units shall be rated in accordance with ARI Standard 240 and bear the ARI label. A full charge of R-410A for

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- 100 feet of refrigerant tubing shall be provided in the condensing unit. A dry nitrogen holding charge shall be provided in the evaporator. System SEER shall meet or exceed 1992 Federal Standards.
- B. Capacities: Provide environmental control air conditioning units of capacity and type as indicated on the drawings and schedules.
- C. Warranty: The units shall have a manufacturer's warranty for a period of one (1) year from date of installation. The compressor shall have a warranty of six (6) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced at the contractor's expense. Manufacturer shall have ten (10) years' experience in the U.S. market.
- D. Components: Provide environmental control air conditioning units that draw air through filter and coils, and that include fans, compressors, cooling coils, reheat coils, filters, remote air cooled condensing units, motors, starters, controls, and all other components necessary for proper operation.
1. Units shall be furnished complete with remote air cooled condensing unit factory assembled and tested by manufacturers of environmental control air conditioning units.
 2. For units installed above ceiling, provide a secondary drain pan with leak detection. Leak detection shall alarm at the building automation system (BAS) and shall de-energize the unit.
- E. Indoor Evaporator Unit: The indoor evaporator unit shall be factory assembled and wired. The casing shall have a white finish. The evaporator fan shall be an assembly with line flow fans direct driven by a single motor. The fan shall be statically and dynamically balanced and run on permanently lubricated bearings. An adjustable guide vane shall be provided with the ability to change the air flow from horizontal to vertical. A motorized air sweep flow louver shall provide an automatic change in air flow by directing the air from side to side for uniform air distribution. Return air shall be filtered by means of an easily removable washable filter. The evaporator coil shall be of non-ferrous construction with smooth plate fins bonded to copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phosphocopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil. The unit electrical power shall be 208 volts, 1 phase, 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts.
- F. Control System: The control system shall consist of two (2) microprocessors interconnected by a single non polar two wire cable as supplied. Wiring shall run from indoor unit to controller direct. NO SPLICES. When running longer lengths or more than one (1) set of remote controller wires together, a double insulated, two wire cable equivalent to that provided e.g. Belden 9407 cable, is mandatory or use shielded two-wire cable. One (1) microprocessor shall be factory wired and located within the indoor unit. It shall have the capability of sensing return air temperature and indoor coil temperature; receive and process commands from the remote controller; provide emergency operation; and control the outdoor unit. The microprocessor within the wall mounted remote controller shall provide automatic cooling; display setpoint and room

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temperature; a 24 hour on/off timer so that automatic operation can be set on the timer at one (1) hour intervals from one to twenty-four hours; have self-diagnostic function display; check mode for memory of most recent problem; control system shall have control continued operation of the air sweep louvers; and provide on-off and system/mode function switching. Normal operation of the remote controller provides individual system control in which one (1) remote controller and one (1) indoor unit are installed in the same room. The remote controller shall have the capability of controlling up to a maximum of fifty (50) systems at a maximum developed control cable distance of 1,650 feet. The control voltage between the remote controller and the indoor unit shall be 12 volts D.C. The control voltage between the indoor unit and the outdoor unit shall be 12 volts D.C. Both 12VDC shall be generated from the indoor unit microprocessor board. The system shall be capable of automatic restart when power is restored after power interruption. System shall include twenty (20) function self-diagnostics including total hours of compressor run time.

- G. Outdoor Unit: The outdoor unit shall be completely factory assembled, piped and wired. The casing shall be fabricated of galvanized steel, bonderized and finished with baked enamel. The unit shall be furnished with one (1) direct drive, propeller type fan arranged for horizontal discharge. The motors shall have inherent protection, be of the permanently lubricated type and resiliently mounted for quiet operation. The fans shall be provided with a raised guard to prevent contact with moving parts. The compressor shall be of the high performance rotary type with crankcase heater, accumulator and internal thermal overloads. The compressor shall be mounted so as to avoid the transmission of vibration. The refrigeration system shall be equipped with high pressure switch and have the capability to operate with a maximum height difference of 100 feet and overall refrigerant tubing length of 100 feet between indoor and outdoor sections without the need for line size changes, traps or additional oil. Refrigerant flow from the condenser to be controlled by means of a capillary tube. The condenser coil shall be of non-ferrous construction with smooth plate fins bonded to copper tubing. The coil shall be protected with smooth plate fins bonded to copper tubing. The coil shall be protected with an integral metal guard. The unit shall be controlled by the microprocessor located in the indoor matching unit. A built-in, low ambient controller will allow cooling to 0 degrees F outdoor temperature. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts.
- H. Wind Baffle: To allow cooling operation in temperature down to zero degrees Fahrenheit, a wind baffle must be installed onto the condensing unit.
- I. Electrical Wiring: Provide all electrical circuits in conformance with NFPA 70 and color coded for ease in field tracing.
- J. Provide five (5) year parts and labor warranty for A/C condensing units.

PART 3 - EXECUTION

3.1 ENVIRONMENTAL CONTROL AIR CONDITIONING UNIT INSTALLATION

- A. General: Install environmental control air conditioning units where indicated on the

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- drawings in accordance with equipment manufacturer's published installation instructions.
- B. Access: Provide access space around environmental control air conditioning units for service as indicated on the drawings, but in no case less than that recommended by the manufacturer.
 - C. Electrical Wiring: Install electrical devices furnished by manufacturer but specified to be factory-mounted. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections.
 - D. Refrigerant Piping: Provide field installed refrigerant piping in accordance with Division-23 section, "Refrigerant Piping."
 - 1. Field installed refrigerant piping shall be refrigerant grade, Type L seamless copper tubing.
 - 2. All connections and joints shall be silver soldered or brazed.
 - 3. Pipe sizing and installation details shown on drawings shall be verified by the manufacturer. Piping shall be installed in strict accordance with manufacturer's recommendations regarding sizing and installation details.
 - E. Piping Connections: Provide piping, valves, accessories, gauges, supports, and flexible connections as indicated on the drawings.

3.2 START-UP

- A. General: Start and adjust all units installed under this specification under the supervision of an authorized factory trained representative of the manufacturer of each unit. Perform operational checks to make certain that controls and safety devices and systems are operating properly. If defects or improper adjustments are found, they shall be corrected and tests repeated.
 - 1. An operational check shall be made to demonstrate compliance with contract requirements, including but not limited to, capacity and control accuracy.
 - 2. A report signed by each factory representative shall be submitted showing test conditions and results.

END OF SECTION 238119

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SECTION 238200 - HEATING AND COOLING TERMINAL UNITS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of terminal unit work is indicated by drawings and schedules, and by requirements of this section and all other Division-23 sections.
- B. Types of terminal units required for project include the following:
 - 1. Convector
 - 2. Unit heaters
 - 3. Cabinet heaters
 - 4. Fan coil units
- C. Refer to requirements of Division-26.

1.2 QUALITY ASSURANCE

- A. Codes and Standards:
 - 1. I=B=R Compliance: Test and rate finned tube radiation in accordance with I=B=R, provide published ratings bearing emblem of I=B=R.
 - 2. ARI Compliance: Provide coil ratings in accordance with ARI Standard 410 "Forced Circulation Air-Cooling and Air-Heating Coils".
 - 3. ASHRAE Compliance: Test coils in accordance with ASHRAE Standard 33 "Methods of Testing Forced Circulation Air Cooling and Heating Coils".
 - 4. ARI Compliance: Test and rate fan coil units in accordance with ARI Standard 440 "Room Fan Coil Air-Conditioners".
 - 5. UL Compliance: Construct and install fan coil units in compliance with UL 883 "Safety Standards for Fan Coil Units and Room Fan Heater Units".
 - 6. ARI Compliance: Test and rate unit ventilators in accordance with ARI Standard 330 "Unit Ventilators".
 - 7. UL Compliance: Provide electrical components for terminal units which have been listed and labeled by UL.

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1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's specifications for terminal units showing dimensions, capacities, ratings, performance characteristics, gages and finishes of materials, and installation instructions.
- B. Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, construction details, and field connection details.
- C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to terminal units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory installed and portions to be field-installed.
- D. Maintenance Data: Submit maintenance instructions, including lubrication instructions, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Handle terminal units and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged terminal units or components; replace with new.
- B. Store terminal units and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.
- C. Comply with Manufacturer's rigging and installation instructions for unloading terminal units, and moving them to final location.

PART 2 - PRODUCTS

2.1 CONVECTORS

- A. General: Provide convectors having cabinet sizes and in locations as indicated, and of capacities, style, and having accessories as scheduled.
- B. Cabinets: Minimum 16-gauge (1.6 mm) steel front and top panels, 18-gauge (1.3 mm) side panels, and 20-gauge (1.0 mm) back panels. Phosphatize and galvanize back panels, phosphatize and paint tops, sides, and fronts, with one coat of primer. Secure fronts in place with quick opening slide bolts or camlock fasteners.
 - 1. Recessed Cabinets: one-piece front panel, with 4-side gasketed overlap.
- C. Elements: Aluminum fins, ribbed steel side plates, fin tube supports and copper tubes, cast-iron headers. Factory test each element to 150 psi (1020 kPa) air pressure under water.
- D. Accessories: Provide the following accessories:

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1. Factory-mounted dampers
2. 1/2" (13 mm) insulation on cabinet back
3. Access doors in front for valve access

2.2 UNIT HEATERS

- A. General: Provide unit heaters in locations as indicated, and of capacities, style, and having accessories as scheduled.
- B. Horizontal Unit Heaters:
 1. Casings: Construct of steel, phosphatized inside and out, and finished with baked enamel. Provide motor-mounted panel, minimum of 18-gauge (1.3 mm) steel. Fabricate casing to enclose coil, louvers, and fan blades. Provide louvers for 4-way air diffusion.
 2. Fans: Construct of aluminum, and factory-balance. Provide fan inlet orifice, smooth, and drawn into casing back panel.
- C. Vertical Unit Heaters:
 1. Casings: Construct of steel, phosphatized inside and out, and finished with baked enamel. Design casing to enclose fan, motor, and coil, design fan orifice formed into discharge panel. Provide air diffusers as scheduled.
 2. Fans: Construct of aluminum and factory-balance. Design so motor and fan assembly is removable through fan outlet panel.
- D. Coils: Construct of plate-type aluminum fins, mechanically bonded to copper tubes. Design coil for use in steam or hot water applications.
- E. Motors: Provide totally enclosed motors, with built-in overload protection, having electrical characteristics as scheduled.

2.3 CABINET HEATERS

- A. General: Provide cabinet heaters having cabinet sizes and in locations as indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coil, fanboard, fan wheels, housings, motor, and insulation.
- B. Chassis: Galvanized steel wraparound structural frame with edges flanged.
- C. Insulation: Faced, heavy density glass fiber.
- D. Cabinet: 16-gauge (1.6 mm) removable front panel, 18-gauge (1.3 mm) top and side panels. Insulate front panel over entire coil section. Provide access door on coil connection side. Clean cabinet parts, bonderize, phosphatize, and flow-coat with baked-on primer.

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- E. Water Coils: Construct of 5/8" (16 mm) seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 300 psi (2070 kPa) and leak test at 300 psi (2070 kPa) under water. Provide same end connections for supply and return.
- F. Steam Coils: Construct of 1" (25 mm) seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 75 psi (510 kPa) and leak test at 450 psi (3060 kPa) under water. Provide cast-iron headers, and same end connections for supply and return.
- G. Fans: Provide centrifugal, forward curved double width fan wheels constructed of non-corrosive, molded, fiberglass-reinforced thermo-plastic material. Construct fan scrolls of galvanized steel.
- H. Motors: Provide shaded pole motors with integral thermal over-load protection, and motor cords for plug-in to junction box in unit.
- I. Filters: Provide 1" (25 mm) thick throwaway type filters in fiberboard frames.
- J. Accessories: Provide the following accessories as indicated and/or scheduled:
 - 1. Wall Boxes: Provide aluminum wall boxes with integral eliminators and insect screen.
 - 2. Recessing Flanges: Provide 18-gauge (1.3 mm) steel flanges for recessing cabinet heaters into wall or ceiling.
 - 3. Sub-bases: Provide 18-gauge (1.3 mm) steel sub-base for vertical units, height as indicated.
 - 4. Extended Oilers: Provide plastic motor oiler tubes extending to beneath top discharge grille.

2.4 FAN COIL UNITS

- A. General: Provide fan coil units having cabinet sizes, and in locations indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coils, fan board, drain pan assembly, fans, housing, motor, filter, and insulation.
- B. Chassis: Construct chassis of galvanized steel with flanged edges.
- C. Insulation: Faced, heavy density glass fiber.
- D. Cabinet: Construct of 18-gauge (1.3 mm) steel removable panels, 16-gauge (1.6 mm) front. Provide insulation over entire coil section. Clean cabinet parts, bonderize, phosphatize, and flow-coat with baked-on primer.
- E. Coils: Construct of 5/8" (16 mm) seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 300 psi (2070 kPa) working pressure, and leak test at 300 psi (2070 kPa) under water.

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- F. Auxiliary Heating Coils: Construct of 7/16" (11 mm) seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 300 psi (2070 kPa) working pressure.
- G. Drain Pans: Construct of galvanized steel. Insulate with polystyrene or polyurethane insulation. Provide drain connection.
 - 1. For units installed above ceiling, provide a secondary drain pan with leak detection. Leak detection shall alarm at the building automation system (BAS) and shall de-energize the unit.
 - 2. A water-level detection device conforming to UL 508 shall be provided that will de-energize the unit should an overflow condition occur at the primary drain pan. The device shall be installed in the primary drain line, the overflow drain line, or equipment supplied drain pan, located at a point higher than the primary drain line and below the overflow of such pan. An alarm shall be generated at EMCS.
- H. Fans: Provide centrifugal forward curved double width wheels of reinforced fiberglass, in galvanized steel fan scrolls.
- I. Motors: Provide motors with integral thermal overload protection. Run test motors at factory in assembled unit prior to shipping. Provide quickly detachable motor cords.
- J. Filters: Provide MERV 7 throwaway type filters.
- K. Dampers: Provide 18-gauge (1.3 mm) steel damper blades with polyurethane stop across entire blade length. Provide factory-mounted electric operators for 25% open cycle.
- L. Accessories: Provide the following accessories as indicated and/or scheduled:
 - 1. Wall Boxes: Provide aluminum wall boxes with integral eliminators and insect screen.
 - 2. Discharge Grille Panels: Provide 18-gauge (1.3 mm) galvanized steel, stamped integral grilles, with access doors.
 - 3. Sub-Bases: Provide 18-gauge (1.3 mm) steel sub-base, height as indicated.
 - 4. Extended Oilers: Provide plastic motor oiler tubes extending to beneath top discharge grille.
 - 5. Provide 3-speed fan (low-medium-high) with accessible selector switch for manual control of fan.
 - 6. Recessing Flanges: Provide 18-gauge (1.3 mm) steel flanges for recessing fan coil units into wall or ceiling.
 - 7. Provide optional extended end pocket (pipe chassis).
 - 8. Control valves shall be provided by the ATC contractor and installed at the factory. Control valve pressure drops shall not exceed coil pressure drops indicated on

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drawings.

9. Provide unit mounted disconnect switch.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which terminal units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF CONVECTORS

- A. General: Install convectors as indicated, and in accordance with manufacturer's installation instructions.
- B. Locate convectors as indicated, coordinate with other trades to assure correct recess size for recessed convectors.

3.3 INSTALLATION OF UNIT HEATERS

- A. General: Install unit heaters as indicated, and in accordance with manufacturer's installation instructions.
- B. Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.
- C. Hang units from building substrate, not from piping. Mount as high as possible to maintain greatest headroom possible unless otherwise indicated.
- D. Support units with rod-type hangers anchored to building substrate.
- E. Install piping as indicated.
- F. Protect units with protective covers during balance of construction.

3.4 INSTALLATION OF CABINET HEATERS

- A. General: Install cabinet heaters as indicated, and in accordance with manufacturer's installation instructions.
- B. Locate cabinet heaters as indicated, coordinate with other trades to assure correct recess size for recessed units.
- C. Install piping as indicated.
- D. Protect units with protective covers during balance of construction.

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3.5 INSTALLATION OF FAN COIL UNITS

- A. General: Install fan coil units as indicated, and in accordance with manufacturer's installation instructions.
- B. Locate fan coil units as indicated, coordinate with other trades to assure correct recess size for recessed units.
- C. Install piping as indicated.
- D. Protect units with protective covers during balance of construction.

3.6 ELECTRICAL WIRING

- A. General: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

3.7 ADJUSTING AND CLEANING

- A. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.
- B. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

3.8 EXTRA STOCK

- A. Filters: Furnish one (1) extra set of filters for each terminal unit to the owner. In addition, install new filters at completion of terminal unit work, and prior to testing, adjusting, and balancing work. Do not operate fans unless filters are in place.
- B. Belts: Contractor shall furnish one (1) spare set of belts for distinct terminal unit size. Deliver to the Owner's representative and mark with the terminal unit size.

END OF SECTION 238200

SECTION 260100 - BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS

- A. Unless otherwise modified, provisions of General Conditions, Supplementary Conditions and Division-01 govern work under the Electrical Divisions.
- B. The drawings and specifications shall be followed in layout of work.
- C. The Architectural drawings shall be used for all dimensional information. Do not scale from the Electrical drawings.
- D. Contract Document Interpretation/Discrepancies:
 - 1. Should the Contractor discover any discrepancies or omissions on the drawings or in the specifications, he shall notify the Architect/Engineer (A/E) of such conditions prior to the bid date. Otherwise, it will be understood that the drawings and specifications are clear as to what is intended and shall be as interpreted by the A/E.
 - 2. In addition, should any contradiction, ambiguity, inconsistency, discrepancy or conflict appear in or between any of the Contract Documents, the Contractor, shall, before proceeding with the work in question, notify the A/E and request an interpretation. In no case shall he proceed with the affected work until advised by the A/E.
 - 3. If the Contractor fails to make a request for interpretation of discrepancies or conflicts in the drawings or specifications, no excuse will be accepted for failure to carry out the work in a satisfactory manner, as interpreted by the A/E. In all cases, the Contractor will be deemed to have estimated the most stringent materials and methods (i.e. the highest quality materials and most expensive manner of completing the work) unless he has requested and obtained written authorization as to which methods or materials will be required.
 - 4. Each and every trade or subcontractor will be deemed to have familiarized himself with all drawings of this project, including Site/Civil, Architectural, Structural, Mechanical, Electrical, Information Technology, etc. so as to avoid coordination errors, omissions, and misinterpretations. No additional compensation will be authorized for alleged errors, omissions, and misinterpretation, whether they are a result of failure to observe these requirements or not.
- E. The complete set of Architectural, Structural, Civil, Technology, Security, Plumbing, Mechanical, and Electrical drawings, specifications, and addenda apply to this work.

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1.2 DESCRIPTION

- A. Unless otherwise modified in other Sections, or on the contract drawings, which define the scope and arrangement of the electrical work to be provided, the applicable provisions of these General Requirements shall govern the furnishing of all supervision, labor, equipment, tools, services, and materials necessary to install a complete electrical system ready for continuous and successful operation. The work shall include, but not be limited to, the furnishing and installation of the following items, as applicable:
 - 1. Electrical services, including metering facilities, meeting the requirements of and in coordination with the local electric power company. Refer to the latest edition of the local power company manuals for service details.
 - 2. Switchboards, power and lighting panelboards, and all required overcurrent devices.
 - 3. Power feeders, branch circuit wiring and disconnect switches for mechanical equipment.
 - 4. Lighting and receptacle feeders and branch circuit wiring.
 - 5. Lighting fixtures with lamps.
 - 6. Exit and emergency lighting.
 - 7. Fire alarm system.
 - 8. Emergency Power Systems, including raceways, wiring and outlets, meeting the requirements of and coordination with the associated companies and the applicable sections of these specifications.
- B. Provide seals for all openings through smoke and fire-rated walls, floors, or ceilings used as passage for electrical conduits, cables, and cable trays per the smoke and fire stopping requirements in this section. This applies to both new and existing penetrations.

1.3 PERMITS, INSPECTION AND CERTIFICATION

- A. Permits: Refer to the General Conditions of the Contract.
- B. Inspections:
 - 1. Refer to the latest edition of the local power company manuals for service inspection requirements.
 - 2. See submittal requirements section of this specification section for additional work related to the inspection documentation needed for all underground work.
- C. Certifications:
 - 1. Certificates of final inspection and approval required by agencies or authorities

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- having jurisdiction shall cover all electrical work.
2. All certificates of final inspection and approval shall be delivered to the Engineer prior to final acceptance of the electrical work.
- 1.4 CODES, STANDARDS AND REFERENCES**
- A. The electrical work covered under the specifications and drawings shall be performed in strict accordance with the latest adopted edition of the following codes and standards:
1. National Electrical Code (NEC), NFPA 70
2. Applicable codes and standards of the National Fire Protection Association (NFPA)
3. National Electrical Safety Code, ANSI C2
4. International Building Code (IBC)
5. All authorities having jurisdiction
- B. The work covered under the specifications and drawings shall be performed using the following references as minimum standards for construction and testing:
1. American National Standard Institute (ANSI)
2. National Electrical Manufacturers' Association (NEMA)
3. Underwriter's Laboratories (UL)
4. The Occupational Safety and Health Act (OSHA)
5. InterNational Electrical Testing Association (NETA)
6. Applicable standards of the utility company and the telephone company
7. American Society of Testing Materials (ASTM)
8. Institute of Electrical and Electronic Engineers (IEEE)
9. Illuminating Engineering Society (IES)
10. Insulated Cable Engineers Association (ICEA)
11. Lightning Protection Institute (LPI)
- C. Electrical construction materials shall, where a listing is normal for the particular class of material, be listed in "Electrical Construction Material List" of the Underwriter's Laboratories, Inc. (UL) and shall bear the listing label. Electrical equipment shall, where a listing is normal for the particular class of equipment, be listed in the "Electrical Appliance and Utilization Equipment List" of the Underwriter's Laboratories, Inc. (UL) and shall bear the listing label. Materials and equipment listed and labeled as "approved for

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the purpose" by a Nationally Recognized Testing Laboratory (NRTL), inspection agency or approved organization shall be acceptable.

1.5 CLARIFICATION OF DRAWINGS

- A. Should a bidder find discrepancies in or omissions from the drawings or specifications, or should he be in doubt in regard to their intent, the Contractor shall notify the Engineer before submitting bid proposal. The Engineer shall then send written instructions to all bidders.

1.6 SUBMITTALS, REVIEW AND ACCEPTANCE

- A. Complete shop drawings and material lists shall be submitted by the Contractor for review by the Engineer in accordance with the requirements of the GENERAL PROVISIONS. Equipment and materials for which shop drawings are not submitted shall be provided as specified, and other manufacturers and products will not be allowed. No work shall be fabricated or ordered by the Contractor until approval has been given by the Engineer.
- B. Complete shop drawings showing dimensions, materials, arrangements, and other pertinent data shall be submitted.
- C. Complete lists of materials and equipment shall be submitted. Full description catalog or other data shall be submitted.
- D. Shop drawings and material lists shall be submitted for, but not limited to the following:
 - 1. Conduit
 - 2. Wire
 - 3. Boxes, Fittings, and Wire Troughs
 - 4. Cabinets
 - 5. Wiring Devices
 - 6. Panelboards
 - 7. Dry-Type Transformers
 - 8. Safety Switches
 - 9. Low Voltage Fuses
 - 10. Enclosed Circuit Breakers
 - 11. Lighting Fixtures and Components
 - 12. Lighting Control Equipment

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13. Switchboards
 14. Metering Equipment
 15. Bus Duct
 16. Floor Boxes
 17. Motor Starters
 18. Remote Control Switches
 19. Automatic Transfer Switches
 20. Emergency Lighting Equipment
 21. As elsewhere indicated on the drawings or in the specifications.
- E. Submit a photographic record of all underground installations, captured prior to concealment. Present adequate quantity and perspectives to convey the entire installation and its compliance with the contract drawings and specifications. Failure to submit a meaningful record may result in a further requirement to excavate portions for review and inspection, at the request of the owner or A/E team, at no additional cost.
- F. Submittals shall include but not be limited to the following information: Size, type, functional characteristics, compliance with standards, required service access which shall be suitable for intended location and use, electrical service connections and requirements, and deviations from Contract Document requirements.
- G. Shop drawings shall include plans, elevations, sections, mounting details of component parts, point to point interconnection diagrams, elementary diagrams, single line diagrams, and any other drawings necessary to show the fabrication and connection of the complete item or system.
- H. Submit shop drawings and/or diagrams for all specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the contract drawings or where the proposed installation differs from that shown on the contract drawings.
- I. Submittals shall include Riser Diagrams and Schematic Wiring Diagrams, complete conduit and wire requirements, outlet and junction box sizes and power requirements, for the following systems:
1. Grounding Systems
 2. Fire Alarm Systems
 3. As indicated elsewhere on the drawings or specifications.

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- J. Submit 1/4" (6 mm) or 1/2" (13 mm) scale plans showing layout of equipment in electrical and communication equipment rooms and closets, elevator machine rooms, etc., indicating sizes of equipment, dimensions, clearances, etc. based on equipment being installed.
- K. Prepare and stamp each submittal in a form indicating that the documents have been contractor reviewed, are complete and are in compliance with the requirements of these contract drawings and specifications.
- L. In general, catalog cuts, specification sheets, descriptive data, etc., shall be acceptable for submittal of all equipment specified by standard catalog numbers, unless otherwise noted in the construction documents.
- M. Shop drawings shall be clearly legible; poor reproductions or reduced photographic copies that are not legible shall be rejected.
- N. Before submission of shop drawings the Contractor shall carefully check same for proper capacity, operating characteristics, physical arrangement accessories, etc., as specified or noted on drawings. If shop drawings are submitted and indicate little or no prior checking by the Contractor, they shall be rejected.
- O. Submittal Identifications:
 - 1. Place a permanent label or title block on each submittal for identification.
 - 2. Indicate name of firm or entity that prepared each submittal on label or title block.
 - 3. Provide a space approximately 4 by 5 inches on label or beside title block to record contractor's review and approval markings and action taken by A/E.
 - 4. Include the following information on label for processing and recording action taken:
 - a. Project name
 - b. Date
 - c. Name and address of A/E
 - d. Name and address of contractor
 - e. Name and address of subcontractor
 - f. Name and address of supplier
 - g. Name of manufacturer
 - h. Unique identifier, including revision number
 - i. Number and title of appropriate specification section
 - j. Drawing number and detail references, as appropriate

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- k. Other necessary identification
- I. Example: 262416-01-0
 - 1) 262416 references the spec section
 - 2) 01 indicates this is the first submittal from this spec section
 - 3) 0 indicates this is the original submittal (where 1 would indicate this is the first re-submittal)
- P. Submittals not in compliance with the requirements of this section will be returned without review.
- Q. Submittals will be checked only for general conformance with the design concept and are subject to the original contract documents, as well as any corrections and comments noted. Comments noted, if any, will not be considered a complete list of all omissions, deviations and corrections necessary to meet the requirements of the contract documents. The contractor will be responsible to confirm that the final product and installation will be in conformance with the contract documents in their entirety, including the responsibility to fully coordinate all work with other trades and to confirm the correctness of dimensions, quantities, and capacities. Submittal review does not authorize or constitute a change to the contract requirements and does not release the contractor of responsibility to conform to the contract requirements. Requirements of the contract are not waived by review of any and all substitutions. The contractor must fulfill the terms of the contract.
- R. Where material or equipment is identified by proprietary name, model number and/or manufacturer, furnish the named item, or equivalent, subject to acceptance. Suitability of only the named item has been verified. Where more than one item is named, only the first named item has been verified as suitable.
- S. Substituted items or items other than first named shall be equal or better in quality and performance and must be suitable for the available space, required arrangement, application and clearances. Submit any and all data necessary to determine the suitability of substituted items. Substitutions must be submitted for consideration seven (7) days prior to the original bid date. Consideration of substitutions shall be at the sole discretion of the Engineer. Substitution submittals shall include all information required in the "Submittals" sub-section of this specification section, as well as all other requirements indicated throughout the Division-26 specifications. All changes incurred as a result of a substitution shall be provided at no additional cost to the Owner.
- T. Substitutions will not be permitted for specific items of material or equipment where specifically noted.
- U. Compliance Review Form: Each equipment submittal must include a Compliance Review Form formatted as follows:
 - 1. Section 1: Certify that the submittal is in complete compliance with the plans and specifications, except for the numbered and footnoted deviations and exceptions as defined herein. Deviations or exceptions taken in a cover letter or by

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contradiction or omission shall not constitute a release from the requirement that the equipment be in complete compliance with the plans and specifications.

2. Section 2: Provide a detailed paragraph by paragraph annotation of the specification with an individual "C", "D", or "E" noted in the margin, as follows:

- a. "C" shall mean compliance with no exceptions. Provide a numbered footnote (i.e. C1, C2, C3, etc.) for each comment or clarification.
- b. "D" shall mean compliance with deviations. For each deviation, provide a numbered footnote (i.e. D1, D2, D3, etc.) with a detailed explanation of how the intent of this specification is to be satisfied.
- c. "E" shall mean exception. The equipment offered is not in compliance with the specifications. For each exception, provide a numbered footnote (i.e. E1, E2, E3, etc.) with a detailed description of the exception.

- V. Electronic Submittals: Should the contractor elect to submit electronic shop drawings/submittals, the procedure shall be as follows:

1. Provide a transmittal with the electronic shop drawing/submittal indicating that the document was transmitted electronically. Transmittal shall also include verification of the contractor's review indicating compliance with the contract documents.
2. Sequentially number all pages on the electronic shop drawing/submittal. The total number of pages shall be reflected in the transmittal.
3. Submittal review comments shall be transmitted electronically. Large documents will be scanned with comments as necessary and returned electronically.
4. All shop drawings such as, but not limited to: coordination drawings, ductwork shop drawings, fire alarm drawings, ductbank layouts, etc. shall be submitted in hard copy, full size format.
5. Provide hard copy of the shop drawing/submittal for each of the Operations and Maintenance Manuals.
6. Failure to comply with the above will result in the submittal being returned and marked "Not Reviewed".

- W. The engineer will provide a maximum of two (2) submittal reviews per equipment submittal; the initial review plus one (1) re-submittal. Should the re-submittal be returned "Not Acceptable" or "Revise and Resubmit", the contractor shall choose one of the following courses of action:

1. Provide the exact manufacturer and model indicated in the contract documents as the basis of design, or
2. Reimburse the engineer for all additional review time required to achieve a submittal review from the engineer of "No Exceptions Taken."

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3. Should the contractor choose option 2 above, the engineer shall be reimbursed at an hourly rate of \$175 per hour with payment due prior to the return of the final submittal. In addition, the contractor shall accept complete responsibility for all delays resulting from the submittal review process extending beyond two (2) reviews per equipment submittal.
- X. Resubmittals: Resubmittals shall comply with paragraph 1.06 of this section and the following additional requirements.
1. Resubmittals shall include a written response to each submittal comment. Provide a detailed comment by comment annotation of the submittal review comments with an individual "C", "D", or "E" as follows:
 - a. "C" shall mean compliance with no exceptions. Provide a numbered footnote (i.e. C1, C2, C3, etc.) for each comment or clarification.
 - b. "D" shall mean compliance with deviations. For each deviation, provide a numbered footnote (i.e. D1, D2, D3, etc.) with a detailed explanation of how the intent of this specification is to be satisfied.
 - c. "E" shall mean exception. The equipment offered is not in compliance with the specifications. For each exception, provide a numbered footnote (i.e. E1, E2, E3, etc.) with a detailed description of the exception.

1.7 RECORD DOCUMENTS

- A. The Contractor shall maintain a record set of electrical prints at the project site and shall indicate thereon any changes made to the contract drawings, including, but not limited to addenda, field sketches, RFI responses, supplemental drawings, sketches, etc. Where changes are made that are reflective of supplemental instructions, revisions, RFI responses, etc., the Contractor shall make clear references to those changes.
- B. A separate set of neat, legible electrical contract prints shall be kept at the project site at all times during the construction of the work for the express purpose of showing any and all changes indicated in paragraph A. above. The prints shall be marked up daily showing all changes to the original documents. The prints shall be marked up in a neat, legible manner using a red pen. Periodic review of the Record Documents will be conducted by the Owner's Representative or A/E. Should this review indicate that the Record Documents are deficient or not up to date, the Contractor shall immediately bring the documents into compliance and make the corrections
- C. Upon completion of the project and before final close-out, the Contractor shall be responsible for producing a final set of record documents in electronic CADD format. One (1) set of full size prints, one (1) CD of the electronic CADD drawings (in AutoCad and pdf format), along with the red-lined marked up field set shall be delivered to the owner upon completion. If requested, the electronic CADD documents shall be uploaded to the owner's FTP site. The final CADD documents shall indicate in the title or revision block "RECORD DOCUMENTS" along with the date completed. The electronic format shall be compatible with the owner's preferred version of AutoCad. Coordinate with the owner before producing the CD or up-loading to the FTP site. Not acceptable

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are contractor installation drawings, shop drawings or multi-layers of work on a single drawing. The final as-built product shall mirror the contract bid documents using the project page layout, format and project title block.

- D. Computer (CADD) files of electrical drawings will be made available to the Contractor upon receipt of a signed waiver (available upon request). One CD will be made available to the general contractor or construction manager for distribution to the trades.
- E. Should the Contractor's electronic Record Documents not be considered complete, they will be returned for completion and/or correction.

1.8 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. Upon completion of all work, the Contractor shall thoroughly instruct the Owner's representatives in the proper operation and maintenance of all electrical equipment and systems. Instructions shall be done only after completed systems have been put into operation and tested for proper operation and performance. Instructions shall be given only by experts in the equipment or systems and shall include descriptions and demonstrations for procedures of operation, data record keeping, etc.
- B. The Contractor shall demonstrate, by actual usage, the proper operation of each and all portions of the various systems to the Owner or his appointed representative. Additional instructional periods shall be provided as required elsewhere in these specifications.
- C. Following completion of the Electrical Contract and prior to the instructional period and final acceptance of the contract, the Contractor shall prepare three (3) Operating and Maintenance Manuals describing the electrical systems and equipment. Data in the manuals shall include, but not be limited to, the following:
 1. Test results for all testing conducted in accordance with Division-26 Section, "Inspections, Testing and Start-up".
 2. List of materials and equipment with name and address of vendor.
 3. List of lamps, fuses (style and ampere rating), overload heaters, and other expendable equipment and devices with type, size or ordering description with name and address of vendor.
 4. Operating, maintenance, and installation instructions for all systems and components with name and address of vendor and servicing supplier.
 5. A certificate of approval from the Electrical Inspector.
 6. A final copy of the approved coordination study.
 7. Final copies of shop drawings and submittals.

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8. Manufacturer's guarantees and warranties.
- D. Manuals shall be of the loose leaf type, in heavy duty binders, with a master index and dividers with plastic tabs indicating system and equipment described.

1.9 RISER PLAQUE

- A. Provide a computer generated riser diagram, 24" x 36" (600 mm x 900 mm) (nominal), of the completed distribution system showing incoming services, switchboard, feeders, transformers, panelboards and related equipment. All feeders and circuits shall be sized and all equipment identified. Drawing shall be framed with plexiglass overlay.

1.10 GUARANTEE

- A. Guarantee obligations shall be as hereinbefore specified in the GENERAL PROVISIONS of these specifications, except as follows:
 1. Guarantee the complete electrical system free from all mechanical and electrical defects for a period of two (2) years beginning from the day of final acceptance of the work or beneficial occupancy by the Owner, whichever occurs first.
 2. During the guarantee period, the Contractor shall be responsible for the proper adjustments of all systems, equipment and apparatus installed by him and do work necessary to insure efficient and proper functioning of the systems and equipment.
 3. Upon receipt of notice from the Owner of failure of any part of the electrical installation during the guarantee period, new replacement parts shall be furnished and installed promptly at no cost.
 4. Within the two (2) year warranty/guarantee period, manufacturer's recommended maintenance shall be provided by the Contractor.

1.11 DEFINITIONS

- A. The following definitions apply to firestopping:
 1. Assembly: Particular arrangement of materials specific to given type of construction described or detailed in referenced documents.
 2. Barriers: Time rated fire walls, smoke barrier walls, time rated ceiling/floor assemblies and structural floors.
 3. Firestopping: Methods and materials applied in penetrations and unprotected openings to limit spread of heat, fire, gases and smoke.
 4. Penetration: Opening or foreign material passing through or into barrier or structural floor such that full thickness of rated materials is not obtained.

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5. Construction Gaps: Gaps between adjacent sections of walls, exterior walls, at wall tops between top of wall and ceiling, and structural floors or roof decks; and gaps between adjacent sections of structural floors.
6. System: Specific products and applications classified and numbered by Underwriters Laboratories, Inc. to close specific barrier penetrations.
7. Sleeve: Metal fabrication or pipe section extending through thickness of barrier and used to permanently guard penetration. Sleeves are described as part of penetrating system in other sections and may or may not be required.

PART 2 - PRODUCTS

2.1 MATERIAL AND EQUIPMENT

- A. All materials and equipment shall be new, the best of their respective kinds and suitable for the conditions and duties imposed on them. Replacement parts shall be available. A permanent service organization maintained or trained by the manufacturer shall be available for service.
- B. The Contractor shall set-in place and connect all electrical equipment furnished under Division-26 and all other Divisions of the Contract.
- C. Verify exact electrical service requirements for each piece of equipment receiving electrical connections. Provide proper service for each.
- D. Include any and all items required by the National Electrical Code and field conditions for the proper connection and installation of each piece of equipment.
- E. Products of one manufacturer shall be used where two or more items of the same kind are required.

2.2 EQUIPMENT DEVIATIONS

- A. The Contractor shall be governed by the requirements of the GENERAL PROVISIONS of these specifications. After an item has been approved, no substitution will be permitted except where such substitution is considered by the Engineer to be in the best interest of the Owner.
- B. The Contractor shall notify the Engineer of any changes in electrical characteristics of equipment being installed as opposed to that specified.
- C. Where the Contractor proposes to use an item of equipment other than that specified or detailed on the drawings, which requires any redesign of the structure, partitions, foundations, piping, ductwork, wiring, or any other part of the mechanical, electrical, or architectural layout, all such redesign, and all new drawings, and detailing required shall, with the approval of the Engineer, be prepared by the Contractor at the Contractor's own expense.

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- D. Where such approved deviation requires a different quantity and arrangement of ductwork, piping, wiring, conduit, and equipment from that specified or indicated on the drawings, with the approval of the Engineer, the Contractor shall furnish and install such ductwork, piping, structural supports, insulation, controllers, motors, starters, electrical wiring and conduit, and any other additional equipment required by the system, at no additional cost to the Owner.

2.3 FIRESTOPPING

- A. All penetrations through fire barriers shall be firestopped with an approved material that is capable of maintaining the fire resistance rating of the barrier. All firestop sealants shall conform to ASTM E 814, ASTM E 119, UL 1479, UL 2079 CAN/ULC S115, and CAN/ULC S101.
- B. Firestop material shall be latex based, intumescent caulk intended for use for all thru-penetrations with piping, ducts, cable trays, conduit, and cables. \
- C. When exposed to high temperatures or fires, the caulk shall expand in volume to quickly close off voids left by melting or burning construction materials. Caulk shall be applied by a standard caulk gun and remain flexible after curing.
- D. Acceptable products shall be limited to Johns Manville "Firetemp-C1;" Hilti "FS-One;" or 3M "CP25WB+." Coordinate with General Contractor such that a single manufacturer/product is utilized throughout the project for all fire and smoke stopping materials.

2.4 SMOKE STOPPING

- A. All penetrations through smoke barriers, smoke partitions, or any other surface required to resist the passage of smoke shall be provided with a smoke stop sealant and/or system that has been independently tested to provide an acceptable smoke seal that will resist the passage of smoke. Smoke stop systems (including product and installation) shall conform to all applicable standards (including but not limited to ASTM, UL and NFPA), as well as all other local, state or federal requirements.
- B. Acceptable manufacturers shall be limited to the manufacturers that may provide firestopping materials/systems (see paragraph 2.03 of this section). Coordinate with the General Contractor such that a single manufacturer/product is utilized throughout the project for all fire and smoke stopping materials.

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PART 3 - EXECUTION

3.1 SUPERVISION AND COORDINATION

- A. The Contractor shall have competent supervision on the site at all times to layout, check, coordinate and supervise the installation of all electrical work and be responsible for the accuracy thereof. He shall plan the installation of all electrical work, giving consideration to the work of other trades, to prevent interference.
- B. Determine the location, size, etc. of all chases, sleeve openings, etc. required for the proper installation of the electrical work and see that such are provided. All chases, sleeves, openings, etc. shall be set prior to erection of new work to prevent delay in the progress of other work or trades.
- C. Conditions and/or situations which prevent the proper installation of any equipment or item where shown on the drawings shall be called to the attention of the Engineer for instructions.
- D. Equipment shall be shipped or fabricated in sections of suitable size for entering the building and being removed from the finished building in the future if necessary.
- E. Fully investigate all peculiarities and space limitations for all materials and equipment.
- F. Outlet, pull and junction boxes and appliances which require operation, examination, adjustment, servicing or maintenance shall be readily accessible.
- G. Take all field measurements necessary for this work and assume responsibility for their accuracy.
- H. Coordinate the electrical work with all sub-contractors. All work shall be so arranged that there will be no delay in the proper installation and completion of any part or parts of electrical equipment. All electrical work shall be installed in proper sequence with other trades without any unnecessary delay.
- I. Make all sub-contractors, suppliers and manufacturers fully aware of all requirements of the Contract.
- J. Coordinate the spacing and arrangement of lighting fixtures, diffusers, grilles and access panels in ceilings to establish a symmetrical pattern. Unless otherwise indicated, items in modular ceiling systems shall be centered in individual tiles.
- K. Coordinate the rough-in of all electrical work performed under other Divisions of these specifications.
- L. Drawings indicate the approximate locations of outlets, apparatus and equipment. The runs of feeders and branch circuits as shown are schematic. Final routing is governed by structural conditions and other obstructions. This does not mean that the design may be changed; it merely refers to the exact run of a raceway between given points.

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- M. The drawings are diagrammatic and indicate the general arrangement of the equipment, the runs of conduit and the manner of connection.
- N. The architectural, structural, mechanical, as well as the electrical drawings, shall be consulted in order to be entirely familiar with conditions to be encountered and special details.
- O. The Contractor shall be solely responsible for the proper arrangement of conduit.
- P. The Engineer shall make all final decisions as to any conditions which require the changing of any work.
- Q. The electrical contractor shall coordinate fully with the elevator inspector for locations of disconnect switches, shunt trip devices, and all associated electrical work prior to installing. Fully coordinate with the elevator contractor's installation of the elevator, lift, walkway, wheel chair lifts, hoistways, etc. prior to laying out and installing any electrical equipment. Should the electrical contractor proceed without this coordination, they do so at their own risk.

3.2 STORAGE AND PROTECTION OF EQUIPMENT AND WORK

- A. All materials and equipment shall be properly and effectively protected by the Contractor during the execution of the work.
- B. All electrical equipment to be used in the construction shall be properly stored and protected against the elements. All equipment shall be stored under cover, and shall not be stored at the construction site on the ground, in mud, water, snow, rain, sleet or dust. Large diameter cables may be stored on reels outside, however, all cable ends shall be waterproofed and the reels covered with weatherproof materials. Such weatherproof materials shall be heavy-duty, securely fastened and made impervious to the elements.
- C. Conventional electrical construction materials such as building wire, outlet and junction boxes, wiring devices, conduit, lighting fixtures, fittings, etc., shall be stored in construction buildings, covered trailers or portable covered warehouses. Any equipment subject to damage or corrosion from excessive moisture shall be stored in dry, heated areas. Any equipment containing plastic or material subject to damage caused by excessive heat or sunlight shall be stored to prevent such damage. This includes plastic ducts and lenses.
- D. All gear and equipment, if delivered to the construction site before the building is under cover and the equipment site prepared shall be warehoused and protected. All gear and equipment shall be covered and protected from the elements and other damage and shall be stored in a clean, dry, heated atmosphere, under cover at the Contractor's expense.
- E. All gear and equipment delivered to the construction site after the building is under cover shall be protected as described above and in addition shall be provided with auxiliary heat to prevent condensation damage. The gear shall also be protected against damage caused by carelessness of workmen who are installing equipment connected to or adjacent to the above electrical equipment.

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- F. Equipment damaged as a result of the above conditions shall be properly repaired at the Contractor's expense or shall be replaced at the Contractor's expense, if, in the opinion of the Engineer the equipment has been damaged to such an extent it cannot operate properly after repairs are made.
- G. All electrical enclosures exposed to construction damages such as paint spots, spackling or plaster spatter, grout splashes, waterproofing compound, tar spots or runs and pipe covering compound splashes, shall be completely covered and protected against damage.
- H. In the event leakage into the building of any foreign material or fluid occurs or may occur, the Contractor shall take all steps as described above to protect any and all equipment.
- I. After connections to electrical equipment are complete and the equipment is ready for operation, all construction debris shall be removed from all enclosures. Such debris includes dust, dirt, wire clippings, tape and insulation removed in order to make connections.

3.3 CUTTING AND PATCHING

- A. All cutting of walls, floors, roofs, ceilings and/or partitions for the passage of conduit, etc., and closing up of superfluous openings around them in connection with the work under this contract, including the removal of all debris caused thereby, shall be performed by the Contractor.
- B. All cutting, patching and finishing shall be performed in accordance with the requirements of the respective division of the specification and shall conform to adjacent work, subject to the approval of the Engineer.
- C. Any work already in place that has been disturbed in the execution of the work shall be repaired and restored in harmony with the surrounding work.
- D. Do not cut structural members without approval of the Engineer.
- E. Patching shall be uniform in appearance and shall match with the surrounding surface.

3.4 PENETRATION OF WATERPROOF AND FIREPROOF CONSTRUCTION

- A. Coordinate the work to minimize penetration of waterproof construction including roofs, exterior walls and interior waterproof construction. Where such penetrations are necessary, provide all necessary curbs, sleeves, shields, flashings, pitch pockets, fittings and caulking to make the penetrations absolutely watertight.
- B. Where waterproofing or fireproofing have been removed or damaged in the execution of the work, the Contractor shall have such damage repaired by the respective trades working on the project.

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- C. Install penetration seal materials in accordance with printed instructions of the UL Fire Resistance Directory and in accordance with manufacturer's instruction.
- D. Seal holes or voids made by penetrations to ensure an effective smoke barrier.
- E. Slots, sleeves and other penetrations in floors, wall or other general construction shall be closed and sealed with an approved firestopping material.
- F. Floor slots and openings shall be closed with 16 gauge (1.6 mm) galvanized steel sheet supported on 1-inch by 1-inch by 1/8-inch (25 mm by 25 mm by 3 mm) structural angle drilled or supported with powder-driven studs into the building structure. Firestop with a layer of firestopping material not less than 1-inch (25 mm) thick which completely fills the opening. The top surface of the firestopping material shall be approximately 1-inch (25 mm) below the finished floor slab.
- G. Openings in walls shall be closed with 16 gauge (1.6 mm) galvanized steel sheet securely attached at the midpoint of the wall thickness and firestopped on both sides of the steel sheet with not less than 1/2-inch (13 mm) thick layer of non-sagging firestopping material to fully cover the opening.
- H. Single or multiple pipes passing through walls and floors shall have the annulus space between pipes or between pipes and structure filled with firestopping material to provide a fire rating equal to the rating of the floors and walls being penetrated. The annulus between exposed conduit and walls or floors in finished spaces shall be filled, sealed, and painted to match adjacent surfaces.
- I. In fire-rated partitions where horizontal separation of opposite-facing electrical boxes is less than 24 inches, provide UL listed firestop around electrical boxes as required to maintain fire rating of wall.

3.5 MANNER OF INSTALLATION

- A. Provide equipment supports consisting of structural racks, hangers, rods, etc.
- B. Equipment supports shall be designed and constructed to safely support and distribute loads evenly over building areas, and withstand stresses to which they may be subjected.
- C. Coordinate the location and installation of supports and sleeves to be set in concrete.
- D. Provide finish metal access doors and frames as indicated or required for access to concealed electrical equipment requiring inspection, adjustment, maintenance, manual operation, etc., or required by code.
- E. In suspended metal pan, lay-in-panel, and accessible tile ceilings, the ceiling element may be used as the access panel.
- F. Access doors in 1-1/2 hour fire-rated construction shall bear the Underwriter's Laboratories "B" label.

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- G. Floor-mounted equipment (switchboards, generators, transformers, sub-stations, motor control centers, starters, control cabinets, etc.) shall be provided with concrete foundations.
- H. Concrete foundations shall be reinforced to suit the loads placed on them and shall be in strict accordance with the equipment manufacturer's recommendations. Concrete materials and methods shall be as specified in Division-3 of these specifications. The Contractor shall refer to this Division to determine specific requirements.
- I. Unless otherwise indicated or required, concrete foundations shall extend 4-inches (100 mm) above the finished floor, at least 3-inches (75 mm) beyond the equipment base in all directions, shall have the top edges chamfered 1" (25 mm) and shall have the same surface finish as the adjacent and surrounding floor. Where equipment weight is such that the floor slab will support the equipment the concrete foundations shall be securely anchored to the floor slab with steel dowels. Properly prepare existing floors: remove paint or dirt, clean and scarify as necessary.
- J. The Contractor shall furnish and set, with proper templates, all anchor bolts and inserts required for the proper attachment of his equipment to the concrete foundations. Anchor bolts shall be of the size and number required by the equipment and/or recommended by the equipment manufacturer and shall be in accordance with the requirements detailed on the drawings and/or specified herein. Anchor bolts shall also be compatible where applicable, with vibration isolation requirements specified for the equipment. Anchor bolts shall be of adequate size and shall engage a steel plate of adequate dimensions cast into the slab.
- K. The drawings indicate the wiring method. The number of current carrying conductors per raceway or cable shall be as indicated. The number of current carrying conductors cannot exceed three (3) per raceway or cable, unless the ampacity adjustment factors of NEC Article 310 are applied.
- L. Each new and existing electrical penetration through a smoke and fire-rated wall, ceiling, or floor shall be sealed with an approved smoke and fire stopping method coordinated with the rating of the associated wall, ceiling, or floor construction.

3.6 CLEANING AND PAINTING

- A. All equipment and conduit shall be thoroughly cleaned of all cutting waste from reaming and tapping. All burrs and other foreign matter shall be removed. Should any part of the system be stopped up by such refuse after the various equipment and apparatus have been accepted, the Contractor shall be required to pay for all labor and materials required to locate and remove the obstruction, and replace and repair all work in any way disturbed thereby. All enclosures, etc., shall be cleaned of all rubbish, plaster, and other debris at the completion of the work.
- B. Paint all exposed metal surfaces, except for galvanized surfaces and extruded aluminum cable and wire duct, of all electrical equipment in mechanical rooms and equipment spaces. Paint all backboards in all telephone and electrical rooms.

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- C. Do not paint nameplates or other elements where such application would interfere with operation or maintenance of equipment.
- D. All scratches or marred areas on factory painted equipment shall be touched up to match finish.

3.7 IDENTIFICATION

- A. Equipment (disconnects, panelboards, starters, relays, switches with pilot lights, pushbutton stations, etc.) shall be identified as to its function, equipment, or area served, etc. In finished areas and mechanical rooms and equipment spaces identification shall be engraved phenolic plates with approximate 3/16" (5 mm) high black letters on white background. Equipment connected to the emergency power system shall be provided with phenolic plates utilizing white letters on red background. Plates shall be attached to front of devices with stainless steel, oval head, machine screws. Panelboards and equipment cabinets shall also be identified with stenciled letters, 3/4" (19 mm) high, on inside of cabinet door, colored to contrast with background.
- B. All conduits containing electrical feeders shall be identified with vinyl cloth pipe markers by W.H. Brady or Seton. Labels shall be applied whenever a conduit enters or leaves a switchboard, panelboard, or a junction or pull box, and at each side of penetrations of walls or floors. Provide individual numbers and letters to indicate feeder number and voltage.
- C. All pull box and junction box covers shall be stenciled to indicate voltage, service and/or system. All stenciling shall be clear and legible from a distance of five (5) feet.
- D. No embossed plastic tape markers will be permitted for use in marking equipment.
- E. All underground feeders, branch circuits, ductbanks, etc. shall be identified with a continuous plastic tape equal to Allen Marking Tape. Tape shall be six inches wide, waterproof, chemically resistant, yellow marked "Caution - Buried Electrical Line Below". Tape shall be located approximately midway from grade to top of feeder.
- F. Receptacle Cover Plates: Provide label on front of cover plate unless otherwise noted. Label shall indicate source panel and circuit number. Label shall be a laminated, adhesive backed, peel-off, polyester type label. Label shall be comprised of a polyester base/substrate and a clear polyester top layer/laminate. The label ink shall be printed underneath the clear polyester laminate. Label shall have black lettering on clear background. Label width shall be a nominal 0.47" (12 mm) wide. Basis of design is the TZe labeling tape by Brother Mobile Solutions, Inc. For use with the Brother P-Touch EDGE Series labeling tools.
- G. All identification shall be subject to the approval of the Engineer.

3.8 EXAMINATION OF SITE

- A. The Contractor shall examine the premises prior to submitting his bid and observe the conditions under which the work will be done or other circumstances which will affect the

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contemplated work. No allowance will be made for any work in connection with any error or negligence on the Contractor's part. No claim for extra compensation will be recognized for difficulties encountered which, in the opinion of the Owner, would have been revealed by proper examination.

3.9 ELECTRICAL DEMOLITION

- A. All demolition of existing electrical equipment, conduit, wiring devices, lighting fixtures, etc. shall be performed under this section of the specification. The areas of demolition are defined on the architectural drawings and specific references are made on the electrical drawings.
- B. The electrical demolition in the renovation areas indicated on the drawings shall be complete and include all electrical work in the area unless noted otherwise.
- C. Existing electrical systems passing through areas of demolition to serve equipment beyond the demolition areas shall remain in service, or be suitably relocated and restored to normal operation, throughout the demolition and reconstruction of the area. The Contractor shall investigate and identify such equipment prior to demolition.
- D. Provide temporary electrical service to equipment disturbed by the demolition until such time as the permanent service can be restored.
- E. The local power company shall disconnect and remove all equipment and facilities that they own and/or maintain. The Contractor shall make and be responsible for all arrangements with the local power company to accomplish removal of their equipment.
- F. Where conduit and wiring to remain are inadvertently damaged or disturbed, cut out and remove damaged portion and all damaged wiring from the source switchboard, panelboard or pullbox to the destination connection point. Provide new wiring of equal capacity.
- G. Exposed conduit and conduit within accessible ceilings, floors and walls to be demolished shall be removed in its entirety, including all conduit, supports, junction boxes, etc. Conduit concealed within non-accessible ceilings, floors and walls abandoned in place, shall be cut flush with walls and floors, plugged, and the adjacent surface patched to match existing.
- H. Wiring to be demolished shall be removed from both concealed and exposed conduit. No wiring which becomes unused as a result of the Contract shall be abandoned in place.
- I. Equipment specified or indicated to be demolished, shall be removed from the project site and shall not be reused. Equipment required to be temporarily disconnected and relocated shall be carefully removed, stored, cleaned, reinstalled, reconnected and made operational.
- J. All material being disposed of shall be done as required to meet the applicable environmental regulations for all local, state, and federal agencies. Examples include, but are not limited to, light fixture ballasts, fluorescent lamps, and batteries.

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- K. Any outages in systems shall be coordinated with the Owner. Where duration of proposed outage cannot be tolerated by the Owner, provide temporary connections as required to maintain service.
- L. Disconnect abandoned outlets and remove devices and wiring back to point of use. Provide blank cover for abandoned outlets.
- M. The contractor shall use care when performing selective building and site demolition. The contractor shall be responsible for damage inclusive of but not limited to: building finishes, lighting (interior and exterior), furniture, structure, site, utilities (above and below ground), mechanical, plumbing, telecommunications and electrical equipment / systems. Should any damage occur or should any remedial work be required, the contractor shall be responsible to repair and or replace the damaged item(s) to the Owner's satisfaction at no additional cost. The contractor shall be responsible for surveying (including contacting Miss Utility), photo documenting and restoring the surrounding work site(s) to the original pre-demolition condition and / or to the Owner's satisfaction upon completion of the work at no additional cost.
- N. Repair adjacent construction and finishes damaged during demolition. Patch all holes left from demolished equipment. Paint surfaces exposed by demolition to match adjacent surfaces.

3.10 CONNECTIONS TO EXISTING WORK

- A. When the work specified hereafter connects to any existing equipment, conduit, wiring, etc., the Contractor shall perform all necessary alterations, cutting, fitting, etc., of the existing work as may be necessary or required to make satisfactory connections between the new and existing work and shall leave the completed work in a finished and workmanlike condition, to the satisfaction of the Engineer.
- B. When the work specified hereafter or under other Sections or Divisions of the contract necessitates relocation of existing equipment, conduit, wiring, etc., the Contractor shall perform all work and make all necessary changes to existing work as may be required to leave the completed work in a finished and workmanlike manner to the satisfaction of the Engineer.
- C. The Contractor is cautioned that all existing electrical systems and life safety systems must remain in service during all phases of construction.
- D. The Contractor shall work in close cooperation with the Owner for any temporary outages.
- E. It is imperative that all interruptions of the electrical service and standby service be kept to an absolute minimum. The Contractor must submit a written request to the Owner for any and all interruptions of the electrical service or the standby service 72 hours in advance of the planned outage.

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3.11 WORKMANSHIP

- A. All materials and equipment shall be installed and completed in a first class workmanlike manner and in accordance with the best modern methods and practice. Any materials installed which do not present an orderly and reasonably neat or workmanlike appearance shall be removed and replaced when so directed by the Engineer. The removal and replacement of this work shall be done, when directed in writing by the Engineer, at the Contractor's expense.

3.12 REPAIR OF EXISTING PROPERTY

- A. All work shall be carefully laid out in advance, and where cutting, channeling, chasing, trenching, or drilling of floors, walls, partitions, ceiling, or other surfaces is necessary for the proper installation, support, or anchorage of raceways, outlet boxes, or other electrical work, this work shall be carefully done, and any damage to building, piping, equipment, or ground shall be properly repaired by skilled mechanics of the trades involved, at no additional cost to the Owner.

3.13 TEMPORARY ELECTRICAL SERVICE

- A. The Contractor shall provide temporary electrical service on the site as is necessary to enable his work and the work of others on the job to proceed and to test the operation of all apparatus, devices, systems which require electrical energy.
- B. The Contractor is responsible for temporary power as may be required for construction or as may be required to maintain critical operations during changeover of feeders or services. The Contractor is responsible for providing all equipment, making all arrangements (including all work needed to submit a service application to the power company), and making all connections required for temporary power.
- C. The Contractor shall disconnect and remove all equipment and facilities required for temporary power at the completion of the project.

3.14 PUNCH-OUT PROCEDURES

- A. Preliminary Punch-out:
 1. Prior to requesting an inspection from the Owner, Engineer, or Permit Official, the General Contractor or Construction Manager (GC or CM) shall provide a preliminary punch-out of the area in question.
 2. Once completed, their punch list shall be supplied to each trade for corrections and completion. The punch list shall also be provided to the Engineer for their use.
 3. Upon being informed that the trade contractors have addressed all of the outstanding items, the GC / CM shall backcheck the work and update the punch list.

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B. Final Punch-out:

1. Final punch-out by the engineer shall not commence until the GC or CM has exhausted their review and has signed off on all items.
2. A copy of the sign-off shall be provided to the Engineer for their record.
3. Once the above has been completed, the Engineer shall be notified that the work is substantially complete and ready for a final punch-out.
4. Depending on the size, schedule, and project complexity, punch-outs may be requested for specific areas or systems, rather than the facility as a whole. Examples of specific requests include the following:
 - a. Above ceiling
 - b. Mock-ups for any repetitive installation to confirm acceptance prior to continuing (labs, dorms, offices, etc.)
 - c. Equipment rooms

END OF SECTION 260100

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SECTION 260200 - PROJECT CLOSEOUT ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

- A. This section provides a summary of the primary electrical project closeout activities, however, this section does not attempt to address all project closeout requirements. Closeout activities referenced in this section include the following:
 - 1. Testing
 - 2. Start-up
 - 3. Punch-out Procedures
 - 4. Operation and Maintenance Manuals (O & M Manuals)
 - 5. Demonstration and Training
 - 6. Record Documents
 - 7. Close-out Documents
- B. This Section shall not supersede any other close-out section or requirements of the Contract. Refer to other Divisions of the specifications and the General Requirements of the Contract for further instructions.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

3.1 TESTING

- A. Either the Contractor or an independent testing firm shall perform systems and equipment inspections and tests as specified in each Division-28 and Division-26 specifications section. Particular attention shall be paid to Division-26 section "Inspections, Testing and Start-up."

3.2 START-UP

- A. The Contractor shall perform start-up on each piece of electrical equipment as specified in each section of Division-26.

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- B. Where indicated in each section of Division-26, the services of a factory authorized and certified technician shall be required to perform the equipment start-up. Start-up by any other organization other than as required by the manufacturer is unacceptable.
- C. Start-up reports shall be provided for all equipment and be included in the final O & M Manuals.

3.3 PUNCH-OUT PROCEDURES

- A. Preliminary Punch-out:
 1. Prior to requesting an inspection from the Owner, Engineer, or Permit Official, the General Contractor or Construction Manager (GC or CM) shall provide a preliminary punch-out of the area in question.
 2. Once completed, their punch list shall be supplied to each trade for corrections and completion. The punch list shall also be provided to the Engineer for their use.
 3. Upon being informed that the trade contractors have addressed all of the outstanding items, the GC / CM shall backcheck the work and update the punch list.
- B. Final Punch-out:
 1. Final punch-out by the engineer shall not commence until the GC or CM has exhausted their review and has signed off on all items.
 2. A copy of the sign-off shall be provided to the Engineer for their record.
 3. Once the above has been completed, the Engineer shall be notified that the work is substantially complete and ready for a final punch-out.
 4. Depending on the size, schedule, and project complexity, punch-outs may be requested for specific areas or systems, rather than the facility as a whole. Examples of specific requests include the following:
 - a. Above ceiling
 - b. Mock-ups for any repetitive installation to confirm acceptance prior to continuing (labs, dorms, offices, etc.)
 - c. Equipment rooms
- C. Upon completion of any and all punch lists (i.e. above ceiling, final, partial, phased, factory review, or specific item) the contractor shall provide an item by item sign-off indicating the date and who completed the item. The sign-off shall be submitted to the A/E and owner before final payment is processed. Should the contractor disagree with any item, they shall provide a written exception giving reason for review.

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3.4 OPERATION AND MAINTENANCE MANUALS

- A. Submit Operation and Maintenance Manuals in three-ring binders with each section separated by tab dividers. Include protective plastic sleeves for any software or folded large documents submitted.
- B. At a minimum, the manual shall contain the following:
 1. Test results for all testing conducted in accordance with Division-26 Section, "Inspections, Testing and Start-up".
 2. List of materials and equipment with name and address of vendor.
 3. List of lamps, fuses (style and ampere rating), overload heaters, and other expendable equipment and devices with type, size or ordering description with name and address of vendor.
 4. Operating, maintenance, and installation instructions for all systems and components with name and address of vendor and servicing supplier.
 5. A certificate of approval from the Electrical Inspector.
 6. A final copy of the approved coordination study.
 7. Final copies of shop drawings and submittals.
 8. Manufacturer's guarantees and warranties.
 9. A full compliance statement, on company letterhead, indicating that all systems are installed and functioning per the contract requirements including drawings, specifications, control sequences and accepted submittals.
- C. The O & M manuals shall be submitted to the A/E for review of general conformance.

3.5 DEMONSTRATION AND TRAINING

- A. Upon completion of work, instruct the owner's representative in the proper operation and maintenance of each electrical system in accordance with applicable specification sections.
- B. Instructions shall be given by persons expert in the operation and maintenance of each system / equipment.
- C. Prepare statement(s) for signing by Owner's representative indicating the date of completion of instructions and hours expended. Furnish copies of signed statements to the A/E.
- D. Final demonstration of all electrical equipment shall be recorded in DVD compatible format. Provide DVD's to the Owner.

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3.6 RECORD DOCUMENTS

- A. The Contractor shall maintain a record set of electrical prints at the project site and shall indicate thereon any changes made to the contract drawings, including, but not limited to addenda, field sketches, RFI responses, supplemental drawings, sketches, etc. Where changes are made that are reflective of supplemental instructions, revisions, RFI responses, etc., the Contractor shall make clear references to those changes.
- B. A separate set of neat, legible electrical contract prints shall be kept at the project site at all times during the construction of the work for the express purpose of showing any and all changes indicated in paragraph A. above. The prints shall be marked up daily showing all changes to the original documents. The prints shall be marked up in a neat, legible manner using a red pen. Periodic review of the Record Documents will be conducted by the Owner's Representative or A/E. Should this review indicate that the Record Documents are deficient or not up to date, the Contractor shall immediately bring the documents into compliance and make the corrections
- C. Upon completion of the project and before final close-out, the Contractor shall be responsible for producing a final set of record documents in electronic CADD format. One (1) set of full size prints, one (1) CD of the electronic CADD drawings (in AutoCad and pdf format), along with the red-lined marked up field set shall be delivered to the owner upon completion. If requested, the electronic CADD documents shall be uploaded to the owner's FTP site. The final CADD documents shall indicate in the title or revision block "RECORD DOCUMENTS" along with the date completed. The electronic format shall be compatible with the owner's preferred version of AutoCad. Coordinate with the owner before producing the CD or up-loading to the FTP site. Not acceptable are contractor installation drawings, shop drawings or multi-layers of work on a single drawing. The final as-built product shall mirror the contract bid documents using the project page layout, format and project title block.
- D. Computer (CADD) files of electrical drawings will be made available to the Contractor upon receipt of a signed waiver (available upon request). One CD will be made available to the general contractor or construction manager for distribution to the trades.
- E. Should the Contractor's electronic Record Documents not be considered complete, they will be returned for completion and/or correction.

3.7 CLOSEOUT DOCUMENTS

- A. Prior to Substantial Completion and /or Final Payment, the Contractor shall prepare and submit the following:
 1. Final punch lists indicating completion of all items.
 2. All record drawings.
 3. All record specifications.
 4. Operation and Maintenance Manuals.

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5. Complete final cleaning.
6. Remove temporary facilities and complete site restoration.

END OF SECTION 260200

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SECTION 260501 - INSPECTIONS, TESTING AND START-UP

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The intent of the inspection, testing, and check-out work specified herein is to ensure that all electrical workmanship and equipment, whether Owner furnished or Contractor furnished, is installed and performs in accordance with the Contract Documents, manufacturer's instructions and all applicable codes and requirements. Also, it is intended to ensure the following:
 - 1. Equipment has not been subjected to damage during shipment or installation.
 - 2. Equipment is in accordance with the specifications.
 - 3. A bench mark is established for routine maintenance and troubleshooting.
 - 4. Successful start-up without last minute interruptions and delays.
 - 5. Each system component is installed satisfactorily and will perform its function reliably throughout its life and the life of the overall system.
- B. Testing requirements in other sections of this Specification are intended to compliment and not supersede nor be superseded by this Section.

1.2 RELATED SECTIONS

- A. Division-01Section - Submittals.
- B. Division-01 Section - Quality Control.
- C. Division-01 Section - Materials and Equipment.
- D. Division-26 - Electrical Specifications.

1.3 REFERENCES

- A. American National Standards Institute (ANSI)
 - 1. ANSI C2, National Electrical Safety Code
 - 2. ANSI Z244-1, American National Standard for Personnel Protection
- B. American Society of Testing and Materials (ASTM)
- C. Institute of Electrical and Electronic Engineers (IEEE)

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- D. Insulated Cable Engineers Association (ICEA)
- E. International Electrical Testing Association (NETA)
- F. National Electrical Manufacturer's Association (NEMA)
- G. National Fire Protection Association (NFPA)
 - 1. ANSI/NFPA 70, National Electrical Code
 - 2. ANSI/NFPA 70B, Electrical Equipment Maintenance
 - 3. ANSI/NFPA 70E, Electrical Safety Requirements for Employee Workplaces
 - 4. ANSI/NFPA 780, Lightning Protection Code
- H. Occupational Safety and Health Administration (OSHA)
- I. State and Local Codes and Ordinances

1.4 SUBMITTALS

- A. Provide resumes for personnel conducting tests and, where used, evidence of the testing firm's qualifications, accreditation and experience.
- B. Provide a list of test equipment to be utilized including the manufacturer's name, model number, serial number, accuracy, and last date of calibration.
- C. Provide industry standards or guide specifications used in lieu of National Standards.
- D. Provide testing procedures and schedules.

1.5 TESTING FIRM

- A. When an independent testing firm is utilized, the following shall apply. The testing firm shall be a competent, independent electrical equipment testing laboratory or organization. The testing firm shall not be a subsidiary, division, nor department of either the installing Contractor or the manufacturer of the equipment materials or systems being inspected and tested. The testing firm shall be a fully accredited member of the International Electrical Testing Association (NETA) and have the specialized experience and skill in the supervision and performance of all inspection and testing specified herein.

1.6 TEST INSTRUMENT CALIBRATION

- A. The testing firm or contractor shall have a calibration program which assures that all applicable test instrumentation is maintained within rated accuracy.
- B. The accuracy shall be directly traceable to the National Institute of Standards and Technology (NIST).

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- C. Instruments shall be calibrated in accordance with the following frequency schedule:
 - 1. Field instruments, analog: six (6) months.
 - 2. Field instruments, digital: twelve (12) months.
 - 3. Laboratory instruments: twelve (12) months.
 - 4. Leased specialty equipment: twelve (12) months.
- D. Calibration labels shall be visible on all equipment and shall have a date of calibration and due date. Calibration records shall be available for review by the Owner.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

3.1 COORDINATION

- A. Provide all necessary supervision and labor, materials, tools, test instruments and other equipment or services required to inspect, test, adjust, set, calibrate, functionally and operationally check all work and equipment.
- B. When an independent testing firm is utilized, provide a set of contract documents to the testing firm.
- C. When an independent testing firm is utilized, provide a copy of the approved short-circuit and protective device coordination study to the testing firm.
- D. Provide the testing firm a set of approved submittals and shop drawings for the equipment to be tested by the testing firm.
- E. Prepare procedures and schedules for all inspections, tests, settings and calibrations specified or otherwise required. The procedures must provide specific instructions for the checking and testing of each component in addition to the system functional checks. All procedures submitted shall include proposed job safety rules.
- F. Provide a suitable and stable source of electrical power to each test site. The testing firm shall specify the specific power requirements. The Owner shall approve all sources of electrical power for testing.
- G. Notify the Owner prior to the commencement of any testing.

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3.2 INSPECTIONS AND TESTS

- A. Equipment purchased by the Contractor or purchased by the Owner but installed by the Contractor shall be inspected and tested to determine its condition.
- B. The inspections, tests and checks described herein shall not be considered as complete and all inclusive. Additional normal standard construction (and sometimes repetitive) checks and tests shall be provided as necessary throughout the project, prior to final acceptance by the Owner.
- C. At any stage of construction and when observed, any electrical equipment or system determined to be damaged, faulty, or requiring repairs shall be reported to the Owner. Corrective action may require prior approval.
- D. Perform routine insulation resistance, continuity and phase rotation tests for all distribution and utilization equipment prior to and in addition to tests performed by the testing firm specified herein.
- E. At the option of the Contractor, either an independent testing firm or the Contractor shall provide testing of the following systems and equipment.
 - 1. 480 volt switchboards
 - 2. 480 volt metal enclosed busway
 - 3. Dry type transformers
 - 4. Grounding systems
 - 5. Ground fault systems
 - 6. Station batteries
 - 7. 480 volt circuit breakers rated 400 amperes and greater
 - 8. Instrument transformers
 - 9. Metering and instrumentation
- F. At the option of the Contractor, either an independent testing firm or the Contractor shall provide visual and mechanical inspections of the following systems and equipment.
 - 1. Panelboards
 - 2. Dry type distribution transformers (600 volt and below)
 - 3. Low voltage wiring (600 volt and below)
 - 4. Molded case circuit breakers rated less than 400 amperes
 - 5. Automatic transfer switches

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6. Motor control
 7. Air switches (600 volt and below)
 8. Lighting control system
 9. Fire detection and alarm system
- G. All circuit breakers and protective devices shall be set and tested at the settings specified in the approved protective device coordination study. All fuses shall be selected and installed in accordance with the approved coordination study.
- H. All circuit breakers and protective devices shall be set as recommended by the manufacturer and tested at those settings. All fuses shall be selected and installed in accordance with the manufacturer's recommendations.
- I. The rotation of all motors shall be checked and corrective action shall be taken where necessary to obtain correct rotation.
- J. Engagement of an independent testing firm in no way relieves the Contractor of the responsibility for the performance of the many and varied tests, checkouts, and inspections required during the various stages of construction.

3.3 CERTIFICATION

- A. Provide certified test reports. Test reports shall meet the criteria specified in OSHA Regulation Part 1907, "Accreditation of Testing Laboratories". The certification shall attest to the fact that the electrical installation has been installed and tested in accordance with the applicable National Standards or, where no National Standard exists, the applicable industry standard or guide specification for the equipment involved.
- B. The following information shall be included in the test reports.
 1. Description of equipment tested (manufacturer, model number, serial number).
 2. Description of test and standards used.
 3. Description of test equipment.
 4. Test results with pass/fail criteria.
 5. Conclusions and recommendations.
 6. Names of personnel conducting the test.
- C. When testing is provided by an independent firm, the report shall be signed by a Registered Professional Engineer.
- D. Provide three (3) copies of the complete test report no later than thirty (30) days following completion of the tests.

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SECTION 260519 - WIRES AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, Basic Electrical Materials and Methods, apply to this Section.

1.2 SUMMARY

- A. The Contractor shall provide, install and terminate all wires and cables for power, lighting, signal, control and related systems rated 600 volts and less.

1.3 SUBMITTALS

- A. Submit product data for electrical wires, cables and connectors.

1.4 QUALITY ASSURANCE

- A. All wires, cables and connectors and the installation of wires, cables and connectors shall comply with the following standards:
 1. NFPA 70 "National Electrical Code."
 2. UL Standards pertaining to wires and cables:
 - a. UL Std 44, Rubber Insulated Wires and Cables
 - b. UL Std 83, Thermoplastic - Insulated Wires and Cables
 - c. UL Std 486A, Wire Connectors and Soldering Lugs for Use with Copper Conductors, UL Std 486B for Use with Copper or Aluminum
 - d. UL Std 854, Service Entrance Cable
 3. Applicable NEMA Standards pertaining to wires and cables.
 4. Applicable IEEE Standards pertaining to wires and cables.
- B. Wires, cables and connectors shall be listed and labeled by UL.

PART 2 - PRODUCTS

2.1 WIRES AND CABLES

- A. All wiring #14 and larger shall be soft drawn copper, 98 percent conductivity, 600 volt insulation, type THHN/THWN.
- B. All wiring connections to lighting fixtures shall have insulation suitable for the temperatures to be encountered in accordance with the NEC.
- C. All wiring #8 and larger for feeders and branch circuits shall be stranded.
- D. Minimum wire sizes shall be #12 for power and lighting circuits and #14 for control circuits unless otherwise noted.
- E. All wiring shall have identification markings along the outer covering denoting conductor size, type of insulation, and manufacturer's trade name. All wiring shall be color coded as follows:

<u>PHASE</u>	<u>120/208 VOLTS</u>	<u>277/480 VOLTS</u>
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
Neutral	White	Gray
Ground	Green	Green

- F. Wiring in sizes up to #8 shall have colored insulation, wiring in sizes #6 and larger shall be coded by colored tape applied no more than 6 inches (150 mm) from each termination and spanning a minimum length of 6 inches (150 mm) of insulation.
- G. All emergency wiring shall be clearly identified as emergency in all outlets, fixtures, etc.
- H. Direct burial conductors and cables shall be Type USE (UL 44).

2.2 CABLE REELS

- A. Cable reels shall retrieve and store loose power cables when not in use. Cable reels shall allow power cables to be pulled out to desired length, locked, and retracted for storage when not in use. Cable locking ratchets shall prevent constant tension on the cable.
- B. A collector ring and brush assembly shall transfer electrical power from the stationary base to the retractable power cable.
- C. Cable reels shall utilize wound steel springs. The reels shall be designed such that less

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- than 70 percent of the available spring turns are used to meet the cable payout specified.
- D. The number and size of conductors of the cable reels shall match the branch circuit ratings indicated on the Drawings. All cable reel assemblies shall include a grounding conductor, and in no case shall the conductors be smaller than #12 AWG.
 - E. Cables shall be type SO extra-flexible for reeling service and consist of a minimum of 65 strands of #30 AWG copper wire. Cables shall have a neoprene oil resistant jacket. Cables shall be provided by the cable reel manufacturer. Cables shall be a minimum of 20 feet (6 m) in length.
 - F. Cable reels shall be of heavy-duty construction suitable for indoor or outdoor service. The cable reels shall be capable of lifting and rewinding a fully extended cable including any accessory wiring device on the end of the cable.
 - G. Cable reels shall be designed to permit payout and retrieval of cable at angles of 0 - 30 degrees from vertical center. Rollers shall be utilized to reduce wear on the cable jacket.
 - H. Cable shall be provided with NEMA 5-20R receptacles constructed from impact-resistant nylon suitable for heavy-duty service. The receptacles shall be completely insulated and shall incorporate an integral cable grip.
 - I. Cable reels shall be provided with junction boxes suitable for hard wiring to the branch circuit indicated on the Drawings.
 - J. Cables shall be provided with adjustable ball stops.

2.3 METAL CLAD (MC) CABLE

- A. The maximum allowable branch circuit conductor size utilizing MC cable shall be #10 AWG.
- B. The following standards shall apply:
 1. UL Standard 1569 for MC Cable
 2. UL Standard 83 for Thermoplastic Insulated Wires
 3. Federal Specification J-C-30B
 4. NEC Article 330
- C. Each circuit conductor and the grounding conductor shall be solid, uncoated copper insulated with PVC and jacketed with nylon complying with the physical and electrical requirements of UL Standard 83 for type THHN.
- D. All cables shall contain a green THHN grounding conductor.
- E. The cables shall be rated 194°F (90°C) and 600 volts.

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- F. Cables which are intended for wiring systems in hospitals, nursing homes, and all other health care related facilities shall comply with NEC - Articles 330 and 517. Cables for use in plenum ceilings shall comply with NEC 300-22 (C).
- G. Fittings: As specified in Division 26 "Raceways" for flexible metal conduits.

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Wiring shall not be installed until building is under roof.
- B. All wiring for lighting and power circuits shall be sized as follows unless otherwise indicated:

<u>120 Volt Branch Circuit Length</u>	<u>Wire Size</u>
0-75' (0-22.5 m).....	#12
75-150' (22.5-45 m).....	#10
Over 150' (Over 45 m).....	# 8

<u>277 Volt Branch Circuit Length</u>	<u>Wire Size</u>
0-200' (0-60 m).....	#12
Over 200' (Over 60m).....	#10

- C. In accordance with the above where the size of branch circuit conductors is increased by the minimum required by the NEC for the branch circuit rating, it is the Contractor's responsibility to ensure that the termination provisions of all equipment connected to such circuits are listed as suitable for the conductor sizes involved.
- D. Emergency lighting and exit sign circuits shall not be installed in raceway, boxes, etc. with other wiring systems, except at lighting fixtures.
- E. Wire pulling compounds shall be polywater or equivalent. The use of oils and greases shall not be permitted.
- F. All field-installed control wire and cable terminating in motor control centers, panelboards, junction boxes, etc. shall be identified with pre-stamped tubular type markers or pressure sensitive linen labels covered with clear heat shrinkable tubing. Labels shall indicate circuit numbers, terminal numbers, etc. of each conductor. The identification labels shall be as manufactured by the W.H. Brady Company, Tyton, or equivalent.
- G. No conductors shall be installed in raceways before the raceway system is properly installed and all work on the building which is liable to injure the conductors has been completed. Immediately before installing the conductors, the raceway, fittings and boxes

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- shall be thoroughly cleaned and dried.
- H. The sharing of the neutral conductor for branch circuits is prohibited unless specifically called for on the drawings.
 - I. Conductors shall be continuous between cabinets, outlets and/or junction boxes; no splices or taps shall be made within the raceway itself. Under no circumstances shall feeder conductors be spliced.
 - J. At least six inches (150 mm) of free conductors shall be left at each outlet, cabinet, junction box, etc. where they are connected or spliced.
 - K. Wiring devices shall not be used as splices; pigtails (line, neutral and grounding) from circuit wiring shall be provided to allow removal of the device without opening the circuit.
 - L. Wiring in cabinets shall be neatly laced or tied.
 - M. Cable reels shall be secured to the overhead structure. Ceiling support wires and framing shall not be used to support cable reels.
 - N. Cable reel ball stops shall be adjusted to provide a maximum retracted height for receptacles at 78 inches (1950 mm) above the finished floor.
 - O. Provide a grounded circuit conductor (neutral) to all wall switch locations.

3.2 METAL CLAD (MC) CABLE INSTALLATION

- A. MC cable shall not be used within electrical rooms, mechanical rooms, janitor's closets, or in any exposed locations.
- B. MC cable shall not be used for feeders.
- C. MC cable shall be clipped directly to walls using clips or straps supplied by the manufacturer. Spacing of supports for non-fire rated circuits shall not exceed 6 feet (1800 mm) on center.
- D. Minimum bend radius shall be as recommended by the manufacturer.
- E. MC cable may be used for lighting whips; maximum 6 foot length, in accessible locations.
- F. MC cable may be used for branch circuits, where concealed.

3.3 TESTING

- A. Feeders shall be checked using a megohm tester to determine the insulation resistance levels prior to energizing.
- B. Branch circuits shall be tested to ensure electrical continuity and to ensure the system is free of short-circuits.

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SECTION 260526 - GROUNDING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies general grounding and bonding requirements for all electrical installations.

1.2 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, "Basic Electrical Materials and Methods", apply to this Section.

1.3 SUMMARY

- A. All systems, circuits and equipment shall be grounded and bonded in accordance with Article 250 of the National Electrical Code and the requirements of these Specifications and the Drawings.

1.4 SUBMITTALS

- A. In accordance with section Submittals and Division-26 Section, "Basic Electrical Materials and Methods", the following shall be furnished:
 1. Test Reports: Certified test reports of ground resistance.
 2. Certifications: Two weeks prior to final inspection, deliver to the Owner six (6) copies of the certification that the materials and installation are in accordance with the drawings and specifications and have been properly installed.
 3. Provide product data for all grounding and bonding components and accessories.

1.5 QUALITY ASSURANCE

- A. All grounding components and accessories shall comply with and shall be installed in accordance with NFPA 70, Article 250 of the National Electrical Code, and applicable sections of UL Std 467, "Electrical Grounding and Bonding Equipment", and UL Std 869, "Electrical Service Equipment".
- B. Grounding and bonding components and accessories shall be UL listed and labeled for the specific application for which they are being used.

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PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING

- A. Provide electrical grounding and bonding components and accessories including, but not limited to, cables and wires, connectors, terminals, jumpers and surge arresters as required for a complete installation.
- B. Where more than one product meets the intended requirements, selection shall be at the discretion of the Installer.
- C. Provide electrical insulating tape, heat-shrinkable tubing, welding materials, straps and jumpers as recommended by manufacturer's written instructions and in accordance with standard industry practices.
- D. All below grade grounding connections shall be exothermic welds and splices and shall be by Caldwell or equal. All materials shall be supplied by one manufacturer to ensure compatibility.

2.2 GROUNDING CONDUCTORS

- A. Provide a grounding conductor with green insulation.
- B. General purpose insulating grounding conductors have insulation types as identified by the NEC and tested, certified, and labeled in accordance with UL Standards.
- C. Non-insulated grounding conductors shall be bare, soft drawn, single or multiple strand annealed copper in wire gauges or sizes as shown on the drawings or consistent with the requirements of NEC Article 250.

2.3 GROUND RODS

- A. Ground rods shall be copper clad, solid steel round bars, 3/4 inches (19 mm) in diameter and 10 feet (3 m) in length.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

- A. All equipment, conduit systems, raceway systems, metallic enclosures of electrical devices, switchgear enclosures, transformer frames and equipment, wiring devices and all metallic non-current carrying devices, etc. shall be completely grounded in accordance with the requirements of the National Electrical Code (latest edition).
- B. Grounding conductors shall be installed within conduit and shall be sized in accordance with NEC Article 250.

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- C. Grounding conductors installed below grade shall be buried at least 24" below grade.
- D. Continuity of rigid steel raceways shall be insured by conduit hubs. All grounded neutral conductors shall be continuously identified. All grounding and bonding connections shall be solderless. All grounding and bonding connections to structural steel shall be exothermic welds. Ground fittings at water system connections shall have rigid clamp jaws. Perforated grounding straps shall not be acceptable.
- E. The secondary neutral conductor of transformers shall be continuous, identified throughout and grounded in an approved manner to the grounding electrode system. Conductor used to ground neutral conductor shall be sized in accordance with NEC Article 250.
- F. Provide insulated grounding conductors for all feeders and branch circuits. Provide grounding blocks, terminals, etc. for connection of ground wires in all distribution equipment, outlets, junction boxes and utilization equipment.
- G. Provide bonding for all metal piping systems and structural steel. Provide bonding connections to cold water and hot water, metal sanitary, gas piping and structural steel. Provide braided copper jumpers at meter, valves, equipment, etc. Bonding shall be in accordance with NEC Article 250.
- H. All grounding wire, lugs, jumpers and bus shall be copper except as specifically approved elsewhere in these Specifications.
- I. Where parallel feeders are used, each raceway shall contain an equipment ground conductor sized in accordance with NEC Article 250 for the combined parallel circuit amperage.
- J. Grounding electrode conductor shall be continuous and no splicing shall be allowed. Equipment grounding conductor splices shall be permitted in device boxes and pulling points, but should be minimized to keep ground resistance as low as possible.
- K. Receptacles shall be bonded to their outlet boxes with #12 copper straps. Straps may be omitted if self-grounding devices are utilized.
- L. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.

3.2 TESTING

- A. The ground resistance at the main switchboard ground bus shall not exceed 10 ohms.
- B. The ground resistance at outdoor pad mounted equipment shall not exceed 5 ohms.
- C. Resistance shall be tested by the fall of potential method according to IEEE 81.
 - 1. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural

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- drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
2. If resistance levels are excessive, take additional steps to reduce resistance to acceptable levels (at no cost to the owner). Drive additional ground rods, provide additional grounding electrode conductors, etc. as needed to reduce resistance. Describe methods used to improve results within test report.
 - D. Certified test results shall be provided in accordance with the requirements of Division-26 Section, "Inspections, Testing and Start-up" of these Specifications.

END OF SECTION 260526

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SECTION 260529 - SUPPORTING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, "Basic Electrical Materials and Methods", apply to this Section.

1.2 SUMMARY

- A. Support all raceways, enclosures, cabinets, boxes, and related electrical equipment from the building structure as required by the NEC and as described in these Specifications.
- B. Support all lighting fixtures as required by the NEC and as described in these Specifications.

1.3 SUBMITTALS

- A. Provide product data for each type of manufactured supporting device.
- B. Provide shop drawings for each type of fabricated supporting device.

1.4 QUALITY ASSURANCE

- A. All components and the installation of all components shall comply with NFPA 70, "National Electrical Code," requirements.
- B. All supporting devices shall be listed and labeled by UL, ETL, CSA or a Nationally Recognized Testing Laboratory (NRTL).
- C. Comply with National Electrical Contractors Association's "Standard of Installation" pertaining to anchors, fasteners, hangers, supports and equipment mounting.

PART 2 - PRODUCTS

2.1 PROHIBITED MATERIALS

- A. Nails, wires, perforated tape or plumber's tape are unacceptable for supporting or securing conduits.

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2.2 MANUFACTURED SUPPORTING DEVICES

- A. Supporting devices shall comply with manufacturer's standard design and construction, fabricated from standard materials in accordance with published product information.
- B. Supporting devices shall be protected with a zinc coating or with a similar corrosion resistant coating or treatment. Devices for use outdoors shall be hot-dip galvanized.
- C. Raceways shall be supported using clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.
- D. Steel channels and associated support rods shall be selected to accommodate weight of associated raceway and wire.
- E. Anchors shall be provided of adequate size to support the load, and shall be compatible with the construction method encountered. Anchors shall be expansion or toggle bolt type.

2.3 FABRICATED SUPPORTING DEVICES

- A. Pipe sleeves shall be fabricated from galvanized sheet steel or Schedule 40 galvanized steel pipe.
- B. Sheet steel sleeves shall be round tube closed with snaplock, joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from the following gauge steel: 3" (75 mm) and smaller, 20 gauge (1.0 mm); 4" to 6" (100 mm to 150 mm), 16 gauge (1.6 mm); over 6" (150 mm), 14 gauge (2.0 mm).
- C. Steel brackets shall be fabricated from angles, channels and other standard shapes. Brackets shall be assembled using welds and/or machine bolts to form a rigid assembly.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install hangers, anchors, sleeves and seals as indicated, in accordance with manufacturer's written instruction and following recognized industry practices to insure supporting devices comply with requirements. Comply with requirements of NECA, NEC and ANSI/NEMA for installation of supporting devices.
- B. Coordinate with other electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices with other work.
- C. Install hangers, supports, clamps and attachments to support piping properly from building structure. Install supports within maximum spacing indicated by NEC or on drawings.

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- D. Individual conduits shall be secured with steel pipe straps or lay-in pipe hangers.
- E. Multiple runs of suspended conduit shall be supported from trapeze style hangers.
- F. Multiple runs of conduit on ceiling or wall surfaces shall be mounted on flush or surface steel channels.
- G. Ceiling support wires shall not be used for support of conduits.
- H. Lighting fixtures shall be supported as recommended by the manufacturer. Recessed LED, incandescent and fluorescent fixtures in suspended ceilings shall not be supported by the ceiling system. Fixtures shall be secured to the building's structure.
- I. Raceway supports shall be adequate to carry present and future load multiplied by a safety factor of at least four. In no case shall a support strength of less than 200 pounds (1380 kPa) be used.
- J. Manufactured watertight and fire-rated seals shall be provided for sealing conduits and cables passing through sleeves in floors and fire-rated walls. Seals shall be fire-resistant rubber plugs or other materials specifically designed to provide a watertight seal and a UL listed fire-resistant rating which meets or exceeds the rating of the floor or wall.
- K. All penetrations through floors or fire-rated walls shall be sealed to restore the fire rating around such penetrations. The sealing system shall fill all voids, shall be specifically designed for such use, and shall have a UL listed fire-resistant rating which meets or exceeds the rating of the floor or wall.
- L. Cable supports shall be provided for vertical conduits in accordance with NEC Article 300. Cable supports shall be multi-section wedge-type plugs with an outside diameter and the number and size of openings required for the conduit and conductors.
- M. Provide vibration isolators between enclosures of all vibration producing equipment, transformers, etc., and their supports or floor. Isolators shall be Mason Industrial type NK neoprene and cork sandwich or equal.
- N. Supports are required within 3 feet (900 mm) of each outlet box, junction box, device box, cabinet, conduit body or other tubing terminations.
- O. All junction boxes shall be supported from structure.

END OF SECTION 260529

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SECTION 260533 - RACEWAYS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, Basic Electrical Materials and Methods, apply to this Section.

1.2 SUMMARY

- A. All wiring shall be installed in raceways as hereinafter specified, unless otherwise indicated.

1.3 SUBMITTALS

- A. Submit product data for raceways, wireways and fittings.
- B. Submit manufacturer's written installation instructions for wireways, surface raceways and non-metallic raceways.
- C. Submit pulling calculations for all underground ductbank runs having cables larger than 4/0.

1.4 QUALITY ASSURANCE

- A. All raceway components and the installation of raceway components shall comply with the following standards:
 1. NFPA 70 "National Electrical Code"
 2. Applicable NEMA Standards
 3. Applicable UL Standards pertaining to raceway system
- B. Raceway components shall be listed and labeled by UL, ETL or CSA.

PART 2 - PRODUCTS

2.1 RIGID METAL CONDUIT

- A. Rigid metal conduits and couplings shall be full weight, heavy wall steel, galvanized, with threaded connections conforming to the latest editions and revisions of ANSI Standard C-80.1 and UL Standard 6 which supersedes Federal Specification WW-C-581.

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- B. Fittings shall be steel or cast malleable iron by Chruse-Hinds, O-Z, T & B, Steel City, Efcor, or equal. O-Z type "AX" or equal fittings with bonding jumpers shall be used in each rigid metal conduit passing across a building expansion joint. Type of fitting shall be properly chosen for the movement anticipated.
- C. Insulating bushings shall be used on all rigid metal conduit terminations and shall be O-Z type "B" or equal.
- D. T & B Series 141, or equal, locknuts shall be used on both inside and outside on all enclosures.
- E. O-Z type "S", or equal, cable supports shall be used in conduit risers as required by the NEC.

2.2 INTERMEDIATE METAL CONDUIT

- A. Intermediate Metal Conduit (IMC) and couplings shall be steel, galvanized, with threaded connections, conforming to the latest editions and revisions of Federal Specifications WW-C-581E and Underwriter's Laboratories Standard 1242.

2.3 ELECTRICAL METALLIC TUBING

- A. Electrical Metallic Tubing (EMT) shall be galvanized, conforming to the latest editions and revisions of ANSI Standard C80.3, Federal Specifications WW-563, and Underwriter's Laboratories Standard 797.
- B. Expansion fitting with bonding jumpers shall be used in each EMT conduit passing across a building expansion joint.
- C. Steel concrete-tight (rain-tight in damp and liquid-tight in wet locations) compression type box connections and couplings with nylon insulating throats shall be used.
- D. O-Z type "SBT" or equal, insulated bushing shall be used on all EMT conduit terminations not in metal enclosures.

2.4 FLEXIBLE METAL CONDUIT

- A. Flexible metal conduit shall be steel, metal strip interlocked construction, zinc-coated, conforming to the latest editions and revisions of Federal Specification WW-C566B and Underwriter's Laboratories Standard for Flexible Steel Conduit, UL1.
- B. Liquidtight flexible metal conduit shall be type UL with PVC cover as manufactured by Anamet: trade name - "Sealtite," or "Hydrotite" as manufactured by Eastern Wire and Conduit or equal, conforming to UL360.
- C. Fittings and Connectors:

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1. Flexible Metallic Conduit: Steel, nylon insulated throat, equal to Crouse-Hinds ACB Series, or Thomas & Betts Tite-bite.
2. Flexible Non-Metallic (Liquidtight): Steel, nylon insulated throat, equal to Crouse-Hinds Liquidator.
3. Die-cast squeeze fittings will not be approved.

2.5 RIGID NONMETALLIC CONDUIT

- A. Polyvinyl Chloride (PVC) conduit shall be heavy wall Schedule 40 or Schedule 80 as noted conforming to the latest editions and revisions of Federal Specifications WC-1094, Underwriter's Laboratories Standard UL651, and NEMA Standard TC-2.
- B. All joints shall be leakproof, moisture-proof, permanent solvent cement type.
- C. Conduit and fittings shall be as manufactured by Carlon, Queen City Plastics or equal.

2.6 RIGID ALUMINUM CONDUIT

- A. Aluminum conduit shall not be used.

2.7 CONDUIT BODIES AND FITTINGS

- A. All couplings, elbows, cast fittings and conduit bodies shall be made of materials of high quality throughout and shall be a first-grade commercial product, well made and free from mechanical imperfections and defects.
- B. Bushings shall be used on all conduits to provide a smooth, well rounded, insulated surface. Bushings shall be metallic with plastic throats. The insulating material shall have a UL temperature rating of 302°F (150°C), it shall be molded-on to the metal and shall become an integral part of the bushing.
- C. Erickson or split couplings shall be used in lieu of running threads. Couplings shall be manufactured by O.Z./Gedney, or equal.
- D. Entrance seals shall be provided where conduits pass through exterior concrete or masonry walls below grade. The entrance seals shall consist of a hot dip galvanized shell, sealing gland assembly capable of providing a seal around the conduit to withstand fifty feet head of water without leakage. The shell of the seal shall have at least two (2) cast collars at a right angle to the sleeve that is embedded in the concrete. Entrance seals shall be O.Z./Gedney Type WSK, FSK or equal.
- E. Conduit hubs shall be malleable iron, zinc plated rain-tight type complete with integral insulated throat, captive O-ring seal and oversize nut. Hubs shall be Myers "Screwtite," O.Z./Gedney "Space Maker," or equal.

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2.8 WIREWAYS

- A. Electrical wireways shall be of the type, size and number of channels as indicated.
- B. Fittings and accessories including but not limited to couplings, offsets, elbows, expansion joints, adapters, hold-down straps, and end caps shall match in form, fit and finish the wireway as required for a complete installation.

2.9 RIGID COATED CONDUIT

- A. Prior to application of the coatings, all conduit shall conform to Federal Specification WW-C-581 E, ANSI Standard C80.1 and UL Standard 6.
- B. Conduit shall be hot-dip galvanized inside and out prior to coating.
- C. Exterior surfaces shall be thoroughly cleaned and treated with an epoxy primer to provide a bond between the zinc and the PVC coating.
- D. Adhesion of the PVC coating to coating and fittings shall be greater than the tensile strength of the PVC coating itself.
- E. PVC exterior coating shall have a nominal thickness of .040" (1 mm) (40 mils) except where part configuration or application otherwise dictate.
- F. Exterior PVC coating on conduit and fittings shall be applied using the fluidized-bed process.
- G. A two-part, chemically cured, urethane coating having a nominal thickness of .002" (.05 mm) (2 mils) shall be applied to the interior surfaces of all conduit and feed-through fittings except where prohibited by design.
- H. Female coupling and fitting threads, as well as all male threads of conduit, elbows, nipples and fittings shall be protected from corrosion by application of two-part, chemically cured, urethane coating.
- I. Each female threaded opening on couplings or fittings shall be protected by an integral PVC sleeve extension formed during the coating process. The sleeve shall extend one pipe diameter or 2" (50 mm) (whichever is less) and have an inside diameter equal to the outside diameter of the uncoated conduit.
- J. Form 8 condulets shall be supplied with stainless steel screws with polyester encapsulated heads. Form 7 condulets shall be supplied with stainless steel screws.
- K. Finished conduit shall fully conform to the current NEMA Standard RN-1 and shall have a label affixed indicating compliance with UL Standard 6.
- L. Interior and exterior coating shall afford sufficient flexibility and elongation to permit field banding without damage.
- M. Approved Material: Perma-Cote supreme as manufactured by Perma-Cote Industries.

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2.10 IDENTIFICATION

- A. Exposed raceways shall be identified at junction and pull boxes and at points not more than 20 feet (6 m) on centers. See Division-26 Section, Basic Electrical Materials and Methods for additional identification requirements.
- B. Labels shall indicate the system voltage and/or type of service and shall have an appropriate legend, such as:
 1. 480 VOLTS - POWER
 2. 480Y/277 VOLTS - LIGHTING
 3. 208Y/120 VOLTS - LIGHTING
 4. 208Y/120 VOLTS - POWER
 5. 120 VOLTS - CONTROL
 6. TELEPHONE
- C. Labels shall appear in white letters of 1/2 inch (13 mm) minimum height on a black background. Labels shall be installed in accordance with the manufacturer's instructions and sizes shall match the conduits to which they are applied. Labels shall be ordered sufficiently prior to their need so that they will be on hand when required for installation. Failure to allow adequate time for delivery of labels, including special legends, will not be considered valid reason for substitution of labels of a different type.

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Exterior locations above grade - rigid metal conduit.
- B. Crawl spaces - intermediate metal conduit.
- C. Exposed locations, up to 10' - 0" (3 m - 0 mm) AFF - intermediate metal conduit.
- D. Exposed locations, above 10' - 0" (3 m - 0 mm) AFF - electrical metallic tubing.
- E. Damp or wet locations - rigid metal conduit.
- F. Within concrete and masonry exterior walls - intermediate metal conduit.
- G. Within concrete floor slabs - rigid nonmetallic Schedule 40 PVC with rigid metal conduit stub-ups.
- H. Below slabs on grade - rigid nonmetallic Schedule 40 PVC with rigid metal conduit stub-ups.

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- I. Direct buried, exterior, feeders - rigid nonmetallic Schedule 80 PVC
- J. Direct buried, exterior, branch circuits (60 amperes or less) - jacketed metal clad cable or rigid nonmetallic Schedule 80 PVC.
- K. Connections to motor terminal boxes, control panels mounted on equipment, dry-type transformers and other vibration producing equipment, dry locations - flexible metal conduit, 18"-36" (450 mm-900 mm) length.
- L. Connections to motor terminal boxes, control panels mounted on equipment, dry-type transformers and other vibration producing equipment, damp and wet locations - liquidtight flexible metal conduit.
- M. Recessed lighting fixtures, between fixture and its respective outlet box - flexible metal conduit in lengths as permitted by the NEC, and providing sufficient slack to permit removal of fixture and access to outlet box.
- N. Minimum conduit size shall be 3/4" (19 mm).
- O. Non-insulating grounding conductors installed within a raceway shall be PVC Schedule 40 (where allowed by Code) or non-ferrous conduit.

3.2 INSTALLATION

- A. Unless otherwise noted on the contract drawings, all raceways shall be installed concealed in the floors, ceilings, walls or partitions of the building, and in such a manner as not to impair the integrity of the structure. Unless otherwise specified, raceways may be installed exposed in mechanical rooms, electrical rooms, large storage spaces and in large janitor's closets, pipe shafts, suspended ceiling spaces, and where required for equipment connections. Exposed raceways shall be installed parallel or perpendicular to walls, structural members or intersection of vertical planes and ceilings, with right angle turns consisting of box-type fittings or symmetrical bends.
 - 1. Exposed conduit in finished areas shall be covered with a 16 gauge steel primed and painted metal cover, secured to an adjacent structure and painted to match adjacent surfaces.
- B. The Contractor shall exercise the necessary precautions to prevent water, dirt, plaster or trash in raceways, fittings and boxes during the course of installation; raceways, fittings, or boxes clogged in such manner that cannot be thoroughly cleaned, shall be replaced. All unconnected conduit ends shall be properly capped. Raceways shall be kept at least 12 inches (300 mm) from parallel runs of flues, steam pipes or hot water pipes. Bends and offsets shall be kept to a minimum, and they shall be made without flattening or deformation with approved hickey or bending machine; the radius of the curve of the inner edge of any field bend shall not be less than the value specified in the National Electrical Code. Raceway runs shall not exceed 100 feet (30 m) between outlets; where necessary, even though not indicated on the drawings, box-type fittings or pull boxes shall be installed. Moisture traps shall be avoided as much as possible. Except as noted, raceways shall not be installed horizontally within concrete slabs-on-grade; raceways shall be installed underground, below the slab. Expansion fittings or

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other approved devices shall be used to provide for expansion and contraction where raceways cross expansion joints.

- C. Raceways shall have supports spaced not more than 8 feet (2400 mm) apart, except in vertical risers where 2 inch (50 mm) and larger rigid metal conduit may be supported at intervals not larger than 15 feet (4.5 m). Raceways shall be supported on approved types of zinc-coated wall brackets, clamps, ceiling trapeze hangers, strap hangers, or pipe straps firmly secured in an approved manner. All ends of raceways shall be reamed to remove rough edges. Raceways shall be firmly attached to sheet-metal enclosures NEMA type 1 by means of proper metallic, plastic throated bushings and locknuts; and to sheet-metal enclosures NEMA types 3, 4, 6, 12 or 13, by means of interchangeable, metallic, plastic-throated, raintight hubs. When installing locknuts and bushings, care shall be observed to see that the full number of threads project through to permit the bushing to be drawn tight against the end of the conduit, after which the locknut shall be made up sufficiently rigid to draw the bushing into firm electrical and mechanical contact with the box; two locknuts, one inside and one outside, plus the bushing, shall be used where required. Proper electrical continuity shall be established throughout the entire raceway system. An approved compound shall be applied to all field threads before installation.
- D. Conduits may be installed in concrete floor slabs with the following limitations:
 - 1. Maximum size - 1-1/4" (32 mm). Conduits larger than 1-1/4" (32 mm) may be installed in concrete floor slabs only with the specific permission of the Architect and Structural Engineer, or as specifically indicated on the drawings, all in accordance with the following limitations.
 - a. Minimum concrete cover - 1" (25 mm), above and below.
 - b. Minimum spacing between conduits - 7-1/2" o.c. (188 mm).
 - c. Maximum conduit outside diameter - 1/3 of slab thickness.
 - d. Installed between bottom and top reinforcing.
 - e. Secured to prevent possible change in positions as concrete is poured.
 - f. Water or damp-proofing integrity of slab is not disturbed.
 - 2. Conduits in close proximity to each other at panelboards, etc., shall be wrapped with wire mesh to prevent cracking of slab.
 - 3. Conduits shall not be installed in post tension slabs.
- E. All conduits shall be tested for clearance and smooth joints and then capped immediately after installation by T & B "push penny" plugs, or equal, to prevent entrance of moisture or debris.
- F. No wire shall be pulled into conduits until system is complete and the building is thoroughly dry.

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- G. Conduits to outlets in demountable or dry wall partitions shall be run in ceiling spaces and not in floor slabs.
- H. Conduits turning from floor slabs up into partitions shall be totally concealed.
- I. Conduits passing from heated to unheated spaces, exterior spaces, refrigerated spaces, cold air plenums, etc., shall be suitably sealed with "Duxseal" by Johns Manville or sealing fittings to prevent accumulation of condensation.
- J. Conduits and sleeves penetrating floor slabs and fire-rated partitions shall have the chopped out space between the outer wall of the piping and the concrete sealed with fire resistant material listed by UL for use in fire rated floor and partition systems. Sleeves penetrating floor slabs shall extend 1-1/2" (40 mm) above the finished floor.
- K. Conduits less than 12" (300 mm) in length connecting outlets of adjoining rooms shall be sealed with "Duxseal" by Johns Manville to prevent noise transmission between rooms.
- L. Pull wires shall be installed in all empty conduits. Use No. 14 AWG monofilament plastic line having not less than 200-lb. (1380 kPa) tensile strength. A minimum of 12 inches (300 mm) of slack shall be provided at each end of the pull wire.

3.3 EXCAVATION AND BACKFILLING

- A. The Contractor shall provide necessary excavation and backfill for the installation of electrical work. The Contractor shall coordinate work with other trades to avoid interference and minimize trenching. Establish all lines and grades required for the proper location of the work and be responsible for the correctness thereof. Verify location and check elevations of all existing utilities before starting work.
- B. Provide guard rails and other necessary safeguards around excavation. Provide shoring, bracing, etc. to protect work, safety of personnel, and existing utilities and underground work. Provide protection against injury of adjacent property. Keep excavation drained and pumped out. Do not permit debris and other materials to enter drains and piping.
- C. Excavate to depth and width required for proper installation of electrical work with minimum clearance of 8 inches (200 mm) on each side and minimum overdepth of 6 inches (150 mm). Excavated materials not required or suitable for backfill shall be removed from the site. Where excess excavation is made, backfill to required level with concrete or crusher run (CR6).
- D. Provide bedding of firmly compacted sand, providing uniform support, to centerline of conduit, duct, ductbank or cable. Minimum depth of sand below conduit, duct, ductbank, or cable shall be three inches (75 mm). Deposit initial layer of backfill, six inches (150 mm) deep, over conduit, duct, ductbank or cable and tamp. Deposit individual layers of backfill in 6 inch (150 mm) layers and tamp. Backfill material under roadway, structures, and equipment, etc. shall be compacted sand. Backfill material shall be free of organic matter, cinders, frozen earth or rock larger than 4 inches (100 mm) in any dimension.
- E. Repair and/or replace any curbs, roads, walks fences, utilities or structures disturbed as a result of the work. Seed or sod all areas disturbed as a result of the work.

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3.4 CLEANING

- A. Inspect all raceways; clear all blockages; and remove all burrs, dirt and construction debris from raceways before installing conductors.

END OF SECTION 260533

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SECTION 260534 - BOXES, FITTINGS AND CABINETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, "Basic Electrical Materials and Methods", apply to this Section.

1.2 SUMMARY

- A. Provide and install outlet boxes, pull and junction boxes, cabinets and enclosures as required by the Drawings and as required by field conditions for a complete installation in accordance with the National Electrical Code.

1.3 SUBMITTALS

- A. Provide product data for all cabinets and enclosures.

1.4 QUALITY ASSURANCE

- A. All items provided under this Section shall be listed and labeled by UL or a Nationally Recognized Testing Laboratory (NRTL).
- B. The components and installation shall comply with NFPA 70 "National Electrical Code."
- C. Enclosures shall comply with NEMA Standard 250, "Enclosures for Electrical Equipment."

PART 2 - PRODUCTS

2.1 METALLIC OUTLET BOXES

- A. Outlet boxes shall conform to UL 514A, "Metallic Outlet Boxes, Electrical," and fittings shall conform to UL 514B, "Fittings for Conduit and Outlet Boxes."
- B. Outlet boxes for indoor and dry locations shall be minimum 4" (100 mm) square or octagonal, 2-1/8 inch (53 mm) deep, zinc-coated sheet steel with stamped knockouts, threaded screw holes and mounting accessories suitable for each location and application. Straps, cable clamps, exterior rings and fixture studs shall be provided as required.
- C. Outlet boxes for outdoor or wet locations shall be minimum 4" (100 mm) square copper-free aluminum cast boxes with threaded raceway entries, threaded screw holes and

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mounting accessories suitable for each location and application. Straps, mounting feet, closure plugs, cable clamps, exterior rings and fixture studs shall be provided as required.

- D. Outlet boxes in concrete construction shall be of sufficient depth to keep conduits a minimum of 1" (25 mm) from the wall surface.
- E. No "thru-wall" boxes shall be used in partitions.
- F. Steel floor boxes shall be sheet steel construction, concrete tight, fully adjustable, with stamped knockouts, adjusting rings, and brass floor plates.
- G. Outlet boxes in masonry partitions shall have square corners with no mounting tabs and shall be of sufficient depth to suit the block or brick construction.

2.2 NONMETALLIC OUTLET BOXES

- A. Nonmetallic outlet boxes shall not be used.

2.3 PULL AND JUNCTION BOXES

- A. Pull and junction boxes over 100 cubic inches (.0016 m³) in volume shall comply with UL Standard 50, "Electrical Cabinets and Boxes."
- B. Boxes shall have screwed or bolted-on covers of the same material as the box and shall be sized to accommodate the application and the site conditions.
- C. Sheet steel boxes shall have welded seams and shall have structural bracing where required to provide a rigid assembly.
- D. All boxes for concealed work shall be constructed of minimum 12 gauge galvanized sheet steel with welded seams and shall be provided with mounting brackets. Integral bracing shall be provided where required to provide a rigid assembly.
- E. All boxes installed in wet locations or on the building exterior shall be constructed from galvanized sheet steel with gasketed covers.

2.4 CABINETS

- A. Cabinets shall conform to UL Standard 50, "Electrical Cabinets and Boxes."
- B. Backboxes shall be constructed from galvanized sheet steel, and fronts and doors shall be constructed from rolled sheet steel. Cabinets shall be NEMA 1 except as otherwise noted. Cabinets shall consist of a box and a one-piece frame front with a hinged door. Concealed fasteners shall secure front to box and provide adjustment to permit alignment of front and box.
- C. Hinges shall be flush, shall not be more than 6" (150 mm) from the top and bottom of the door, and shall be no more than 24" (600 mm) apart. Doors greater than 48" (1200 mm)

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- in height shall have 3-point latching mechanism.
- D. Surface mounted cabinets shall have fronts of the same height and width as the box. Flush mounted cabinets shall have fronts which extend 3/4" (19 mm) beyond box in all directions.
 - E. Double doors shall be provided for cabinets wider than 24" (600 mm).
 - F. Doors shall have combination spring catch and key lock. All locks for cabinets of a common system shall be keyed alike.

PART 3 - EXECUTION

3.1 OUTLET BOXES

- A. Outlet boxes shall be firmly secured in place, plumb and level. Outlet boxes installed in suspended ceilings shall not be supported from the ceiling system. Outlet boxes for like devices shall have a uniform mounting height unless specifically noted otherwise.
- B. Outlet boxes over windows and doors shall be installed 7'-6" (2250 mm) above the finished floor, centered over the door or window unless otherwise noted.
- C. Outlet boxes shall be 6"-12" (150 mm-300 mm) from the strike side of the door frame when installed adjacent to a door opening.
- D. Outlet boxes at fixed work surfaces and counter tops shall be installed with the center of the box 6" (150 mm) above the work surface or counter surface unless otherwise noted.
- E. Covers shall be installed on all outlet boxes.
- F. Outlet boxes for wall mounted video equipment shall be installed with the center of the box 80" (2000 mm) above the finished floor or 6" (150 mm) below the finished ceiling, whichever is lower.
- G. Outlet boxes for electric water coolers shall be wall mounted and shall not be visible after the water cooler is installed. Mounting height shall be coordinated in the field.
- H. Coordinate outlet box locations with baseboard heating units. Contractor shall adjust box locations where necessary to accommodate installation and listing requirements of baseboard heating units. Advise Owner/Engineer of any necessary adjustments. Outlet boxes shall be installed above hydronic baseboard heat and below electric baseboard heat.
- I. Outlet box mounting heights are as indicated. Mounting heights shall be to the center line of the box.

3.2 PULL AND JUNCTION BOXES

- A. Pull and junction boxes shall be no smaller than 8 inches (200 mm) square by 4 inches

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- (100 mm) deep.
- B. Boxes shall be the minimum size as required by the National Electrical Code or larger as indicated on the Drawings.
 - C. Junction and pull boxes shall be furnished and installed where indicated on the Drawings or where required by the NEC.
 - D. Boxes for communication, data and signaling systems shall be 50 percent larger than the size required by the NEC and shall be located to permit ready access for installation of future raceways and conductors.

3.3 CABINETS AND ENCLOSURES

- A. Fronts of cabinets and enclosures shall be mounted straight and plumb with building surfaces.
- B. Cabinets and enclosures 68" (1700 mm) or less in height shall be installed with the top of the cabinet or enclosure 72" (1800 mm) above the finished floor. All cabinets and enclosures shall be installed in accordance with the NEC.
- C. Cabinets and enclosures installed adjacent to one another shall be installed with the tops of the cabinets and enclosures at the same height.
- D. Cabinets and enclosures in finished areas shall be flush with the walls. Cabinets and enclosures in mechanical and electrical rooms shall be surface mounted unless otherwise noted.

3.4 GROUNDING

- A. All metallic boxes, cabinets and enclosures shall be effectively grounded in accordance with Article 250 of the NEC.
- B. Provide a grounding terminal in the interior of all boxes, cabinets and enclosures.

3.5 CLEANING

- A. After installation, clean and repair all boxes, cabinets and enclosures. Galvanized finishes shall be repaired using a zinc-rich paint as recommended by the manufacturer. Painted finishes shall be repaired using a matching paint from the manufacturer.

END OF SECTION 260534

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SECTION 260573 - COORDINATION STUDY

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The Contractor shall engage the services of a qualified professional engineer to perform a short circuit and protective device coordination study and an arc flash hazard analysis. The Contractor is responsible for providing all pertinent information required by the preparers to complete the study. The study shall be performed in strict accordance with these specifications.
- B. The study shall include all portions of the electrical distribution system from the utility overcurrent device to the 208Y/120 volt branch circuit panelboards. The contractor is responsible for field surveying all portions of the existing electrical distribution system including those portions not shown on the partial electrical single line. As part of the study the contractor shall develop and provide for the owner's use a complete, comprehensive and accurate electrical single line for the building.

PART 2 - PRODUCTS

2.1 SHORT CIRCUIT STUDY

- A. The Contractor shall provide a short circuit study for the electrical distribution system. The study shall include the calculation of three phase bolted fault values and phase to ground fault values at every point of application of a protective device on the system. Momentary and interrupting duty values shall be calculated.
- B. Obtain a letter from the utility company indicating what the available fault current and X/R ratios are at the service entrance. Provide the letter in an appendix of the report.
- C. The short circuit calculations shall be performed by a computer program. Provide a computer generated single line diagram showing calculated and rated fault levels for each piece of electrical equipment.
- D. The short circuit study report must include a complete index of fault bus identifications. A system diagram indicating system configuration and the fault bus locations shall be provided in the study.
- E. Provide a complete printout of the results of the calculations.
- F. Momentary duty fault values shall be tabulated for both three phase and phase to ground faults including: bus identification, bus L-L voltage, symmetrical fault current values, symmetrical fault kVA values, and X/R ratio at each fault bus.
- G. Interrupting duty fault values shall be tabulated for both three phase and phase to ground

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- faults including: bus values, symmetrical fault kVA values, X/R ratio at each fault bus, asymmetry factor at each fault bus, and the associated asymmetrical fault value at the bus.
- H. Manufacturer's published interrupting/withstand capabilities shall be compared to calculated fault current values to determine acceptability of each protective device installed on the system. A tabulation shall be provided detailing the comparison.
 - I. The short circuit study shall report any deficiencies in interrupting capabilities and include recommendations for correcting such deficiencies.

2.2 PROTECTIVE DEVICE COORDINATION STUDY

- A. The Contractor shall provide a protective device coordination study for all protective devices installed on the electrical distribution system.
- B. The coordination study shall begin with the first upstream utility protective device and continue down through the distribution system to the first device on each feeder which does not have adjustable trip characteristics.
- C. Time-current coordination curve sheets shall be developed on log-log paper utilizing manufacturer's published time-current characteristics. Key coordination elements shall be plotted to demonstrate the level of coordination provided.
- D. Transformer damage characteristics as specified in American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI and IEEE) guidelines and inrush points shall be plotted to demonstrate the level of protection provided. Cable insulation withstand curves shall also be plotted to demonstrate protection provided.
- E. Each curve sheet shall have a single line diagram indicating the portion of the system being plotted.
- F. Each curve sheet shall be accompanied by a detailed narrative explaining the coordination provided, and any compromises made between protection and selectivity.
- G. The coordination study report shall provide complete tabulations of all protective devices, ratings and settings. Recommendations shall be provided to improve coordination where necessary.

2.3 ARC FLASH HAZARD ANALYSIS

- A. Provide arc flash hazard calculations for all electrical distribution equipment identified in NEC Article 110.16, Flash Protection.
- B. Provide arc flash hazard calculations per IEEE-1584. Calculations shall provide the flash protection boundary (ft.), arc flash hazard category and the required personnel protective equipment (PPE) for all electrical distribution system equipment included in the Arc Flash Hazard Analysis. Also provide incident energy level as calculated in analysis.

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- C. Provide an arc flash hazard warning label on all electrical distribution system equipment included in the Arc Flash Hazard Analysis. The label shall comply with ANSI Z535.4-1998, Product Safety Signs and Labels. The label shall include, but not be limited to, the flash protection boundary, flash hazard category, and required PPE.

PART 3 - EXECUTION

3.1 REPORT

- A. The short circuit and coordination study shall be completed prior to releasing for manufacture of all switchboards, fused switches, panelboards, circuit breakers and other equipment with overcurrent protection.
- B. Six (6) copies of a bound report shall be submitted for review and approval at the completion of the short circuit and coordination study. The report shall contain all of the items required by these specifications. The report must be submitted prior to the delivery of any distribution equipment submittals. Submittal reviews of distribution equipment shall be withheld until the report is received, reviewed, and approved.
- C. Time-current coordination curve sheets may be reduced to 8-1/2 x 11 size for inclusion in the report. However, full size curve sheets shall be provided, not necessarily bound, with each copy of the report.
- D. The Contractor shall warrant that errors and omissions in the study or report shall be corrected without charge to the Owner when so found within twelve (12) months from acceptance of the first report.
- E. Copies of the approved study shall be included in the manuals specified in Division-26 Section, "Basic Electrical Materials and Methods."

END OF SECTION 260573

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SECTION 260943 - LIGHTING CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

- A. The following specifications detail the minimum performance and related criteria for a lighting control system proposed for this project.

1.2 RELATED SECTIONS

- A. Division-26 Section, Wiring Devices.
- B. Division-26 Section, Lamps and Ballasts.

1.3 SYSTEM DESCRIPTION

- A. System shall consist of factory pre-assembled dimming and switching panels, centralized preset lighting control(s), and line voltage and low voltage wallstations and/or control interfaces, and solid-state high frequency fluorescent dimming ballasts (where applicable). Additional items may also be required and are described herein and/or shown on the drawings.

1.4 SUBMITTALS

- A. Shall include a load schedule which indicates the actual connected load and load type per circuit, circuits and their respective control zones, circuits that are on emergency (if applicable), and the capacity, phase, and corresponding circuit numbers (per the electrical drawings).
- B. Shall include a complete schematic of the system.
- C. Shall include catalog cut sheets with performance specifications including historical testing data demonstrating complete compliance to all of the specifications herein.
- D. Shall include written certification of compatibility of all lighting controls.
- E. Shall include all exceptions taken to the specification.
- F. Shall be submitted for approval a minimum of ten (10) business days prior to bid date for all materials other than those specified herein.
- G. Manufacturer shall provide any additional information or factory demonstrations as required by the specifier to demonstrate conformance with Part 2 of this specification. All demonstrations are to be at a location, time and in a manner chosen by the specifier.

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1.5 QUALITY ASSURANCE

- A. Manufacturer shall have a minimum of ten (10) years continuous experience in the manufacturing of lighting controls.
- B. Lighting control system shall be UL listed specifically for the required loads (i.e. incandescent, magnetic and electronic low voltage, fluorescent, etc.). Manufacturer shall provide evidence of compliance on request.

1.6 PROJECT/SITE CONDITIONS

- A. Lighting control system shall operate in an ambient temperature range of 0°C (32°F) to 40°C (104°F) and 90% non-condensing relative humidity without the requirement of a regularly scheduled maintenance program for air filtration components.

1.7 WARRANTY

- A. Manufacturer shall provide a full two (2) year warranty. The warranty shall cover 100% of the cost to repair or replace any parts required over the first two (2) years, which are directly attributable to the manufacturer.

1.8 COMMISSIONING

- A. The contractor shall provide the manufacturer with ten (10) working days' notice of the scheduled commissioning date.
- B. Upon completion of the installation, the system shall be completely commissioned by a factory-employed engineer. The check-out will be performed after all loads have been tested live for continuity and freedom from defects and that all control wiring has been connected and checked for proper continuity. The factory-employed engineer shall demonstrate and educate the owner's representative(s) on the system capabilities, operation and maintenance.
- C. Manufacturer shall offer extended warranty based upon successful factory commissioning.

PART 2 - PRODUCTS

2.1 BASIS OF DESIGN

- A. Lighting Control System Basis of Design shall be Lehigh Lighting - E-Flex lighting and energy control system.
- B. Eaton Lighting Systems – Control Keeper System shall be an allowable manufacturer.
- C. Legrand – Wattstopper shall be an allowable manufacturer.

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2.2 WALLBOX PRESET CONTROLS, DIMMERS, SWITCHES AND WIRING DEVICES

- A. Refer to Division-26 Section, Wiring Devices for details.

2.3 OCCUPANT SENSORS

- A. All occupant sensors shall be provided by one manufacturer.
- B. All occupant sensors shall be capable of central control by the lighting control system, unless otherwise noted on the drawings.
- C. Occupant sensors shall incorporate ultrasonic motion sensing technology.
- D. Occupant sensors shall incorporate adjustable sensitivity to cover various room sizes.
- E. Wall Switch Occupant Sensors:
 - 1. Wall switch occupant sensors shall be capable of controlling 6.7 amps at 120 volts or 4.3 amps at 277 volts.
 - 2. Wall switch occupant sensors shall detect minor hand motion in rooms up to 300 square feet.
 - 3. Wall switch occupant sensors shall provide the option for automatic or manual on and off control.
- F. Ceiling-Mounted Occupant Sensors:
 - 1. Ceiling-mounted occupant sensors shall be capable of controlling 16 amps at 120 volts or 277 volts with power-pack relay.
 - 2. One-way ceiling-mounted occupant sensors shall detect minor hand motion in rooms up to 575 square feet. Two-way ceiling-mounted occupant sensors shall detect minor hand motion in rooms up to 1345 square feet.
 - 3. Ceiling-mounted occupant sensors shall provide automatic on and off control.
 - 4. Ceiling-mounted occupant sensors shall have Teflon insulated wires that are fire-rated for mounting in ceiling plenums.

2.4 ELECTRONIC FLUORESCENT DIMMING BALLASTS

- A. Refer to Division-26 Section, Wiring Devices for details.

2.5 POWER PANELS

- A. Panels shall be UL listed or CSA, NOM or CE approved (where appropriate). Panels shall be wallmounted NEMA grade, gauge as required by UL508. Contractor shall reinforce wall as required for wall-mounted panels.

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- B. Panels shall be completely pre-assembled and factory tested by the manufacturer. The contractor shall be required to provide input feed wiring, load wiring, and control wiring. No other wiring or assembly by the contractor shall be permitted. All input feed, load, and control terminals shall be front accessible without the need to remove dimmer assemblies or other components.
- C. Unless the panel is a dedicated feed-through switching panel or otherwise indicated, panels shall contain branch circuit protection for each dimming assembly. Branch circuit breakers shall have the following performance characteristics:
 - 1. UL listed under UL 489 or meet IEC 60898 as a molded case circuit breaker for use on lighting circuits.
 - 2. Contain a visual trip indicator and shall be rated at 10,000 AIC (120V), 6000 AIC (230V) and 14,000 AIC (277V), unless otherwise noted.
 - 3. Thermal-magnetic in construction for both overload and dead short protection. The use of fully magnetic breakers shall not be acceptable, even when used in conjunction with individual dimmer thermal cutouts.
 - 4. Replaceable without moving dimmer assemblies or other components of the panel.
 - 5. For 120V and 277V, shall be switching duty (SWD) rated so that loads can be switched off via the breakers.
- D. Activation of a circuit protection device shall affect only the single dimmer that it is wired to protect.
- E. Panels shall be equipped with an electronic BYPASS feature which electronically switches lighting loads to full light output from any level by toggling the individual branch circuit breakers (for individual circuits) or main breaker (for all circuits) when there is no intensity data available from the control system.
- F. Panels which allow the dimmers to be loaded to greater than 80% of the wiring ampacity as specified by NEC shall not be acceptable.
- G. Panels requiring the neutral feeder to be sized larger than any individual phase feeder shall not be acceptable.
- H. Panels shall be shipped with each dimmer in a mechanical BYPASS position via a jumper bar inserted between the input and load terminals to allow dimming panel to be used as a temporary lighting panel with no threat to the dimmer. These jumpers shall carry the complete load current and shall be reusable at any time.
- I. Panels shall be capable of maintaining dimmers at current light levels in the event of a control failure. Systems that fail to off during a control failure are not acceptable.
- J. Panels shall be passively cooled via free-convection, unaided by fans. Systems that are fan dependent or fan assisted, or which recommend regularly scheduled maintenance for air filtration components are not acceptable.

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- K. Panels shall provide a minimum of 52 square inches of cooling surface area for each semiconductor.
- L. Panel shall provide capability to electronically assign each circuit to any zone in the dimming system. Panels using mechanical switches, rewiring, or EPROMS shall not be acceptable. All circuits shall be capable of being operated (dimmed or switched where appropriate) from the panel.
 - 1. Where indicated on the drawings, dimming and switching panel(s) shall be capable of operating under two optically isolated control systems. Panel shall be capable of auto detecting between Manufacturer's control protocol and DMX512 protocol for each control system. Panel response to control changes shall take no more than 25 milliseconds. Panel shall be capable of assigning each dimmer to either control system on a circuit by circuit basis. Panel shall also be capable of conditionally changing assignment from one system to the other.
- M. Multiple panels shall be capable of operating in one system.
- N. Panels shall be able to be controlled by a central BAS system using BACnet.
- O. For panels fed with a normal/emergency feeder, panel shall include electronics to bring all circuits to an emergency full-on condition upon the loss of normal power and the subsequent presence of emergency power. Designated circuits shall be controlled simultaneously with other lighting circuits within the designated control zone during the presence of normal utility or generator power.
 - 1. Panels listed as emergency shall have all circuits immediately go to a full-on condition. All dimmers shall operate at 100% of input voltage, bypassing any high-end trim. All local control stations are inoperable during this period. Once normal power is restored, all lighting zones shall revert back to their status prior to the emergency condition without requiring any action on the part of the user. Restoration to some other "default" level is not acceptable.
 - 2. This type of emergency full on may be used with either a normal/emergency generator, UPS or IPS system with true sinewave output and maximum of 10% THD. The generator, UPS, or IPS system must be capable of operating under no load conditions or a constant hot secondary utility feed where the emergency transfer occurs on the line side (upstream) of the dimming panel and requires that only a single normal/emergency feeder be brought to the Emergency Dimmer Panel.
 - 3. System shall be capable of meeting local jurisdictions requiring special conditions such as minimum light levels during normal operation or full function, even during emergency power.
- P. Panels shall be capable of bypassing all dimming and switching devices to turn all fixtures to full brightness during a fire alarm or security event via input from an emergency contact closure.
- Q. Panels shall be compatible with DMX control and shall be capable of accepting control signals from a third party architectural lighting system via DMX.

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- R. Panels shall be provided with an integral time clock where indicated on the drawings. Time Clock shall execute any of the following events: select preset scenes, lockout control stations, or unlock control stations. Commands can either be in real or astronomic (relating to sunrise/sunset) time. Time clock shall automatically correct for daylight savings time and leap year where appropriate. There shall be a total of ten (10) time clock schedules available per room or area (one per day of each week, plus three special schedules). Any special schedules that have been programmed shall be capable of being stored in a "calendar" format on a screen up to a year in advance for easy reference. The time clock shall be capable of executing up to 600 events per day. The time clock can be enabled or disabled for any area via either the set-up computer or local wallstation/control interface.

S.

2.6 MODULAR DIMMING ASSEMBLIES

- A. Dimmer shall be capable of withstanding inrush current of 50 times operating current. In addition, under fully loaded operating conditions, all semiconductor devices shall operate at a minimum 20°C (68°F) safety margin below the component temperature rating.
- B. A positive air gap switch shall be employed with each dimmer in the panel to ensure that the load circuits are open when the "off" function is selected from the control system.
- C. Each dimmer shall compensate for incoming line voltage variations such as changes in RMS voltage, frequency shifts, harmonics and line noise. Dimmer shall be capable of maintaining constant light level with no visible flicker under the following conditions:
 - 1. $\pm 2\%$ change in RMS voltage/cycle
 - 2. ± 2 Hz change in frequency/second
 - 3. Dimmers that do not regulate the dimmer output in real time shall be unacceptable.
- D. Each dimmer shall incorporate an electronic "soft-start" default at initial turn-on that smoothly ramps the lights up to the appropriate levels within 0.5 seconds.
- E. Once installed as part of a complete system, the semiconductor used to control the power furnished to the loads shall be both designed and tested to withstand surges, without impairment to performance, of 6000V, 3000A (equivalent to a near lightning strike) as specified by ANSI/IEEE Std. C62.41. Upon request, the Manufacturer shall provide a means to demonstrate conformance to this specification using the appropriate surge-generation equipment.
- F. One type of dimmer shall be used for all sources, line voltages, and frequencies. Systems requiring different types of modules shall not be acceptable. Dimmer shall be capable of electronic assignment to any source and any zone. Upon replacement of a dimmer, only that dimmer shall require replacement, and no re-programming shall be required.
- G. Dimmer output voltage shall be a minimum 95% of input voltage at maximum intensity

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setting.

- H. Dimmer shall include diagnostic LEDs to verify proper operation and assist in any system troubleshooting.

2.7 MODULAR SWITCHING ASSEMBLIES

- A. Assembly shall be capable of withstanding inrush current 75 times operating current. In addition, under fully-loaded operating conditions, all devices shall operate at a minimum 20°C (68°F) safety margin below the component temperature rating.
- B. A positive air gap switch shall be employed with each circuit in the power panel to ensure that the load circuits are open when the "off" function is selected from the control system.
- C. Relays shall be mechanically latching. Relays shall be of sealed construction type in order to prevent contact degradation.
- D. Once installed as a complete system, the relays used to control the power furnished to the loads shall be both designed and tested to withstand surges, without impairment to performance, of 6000V, 3000A (equivalent to near lighting strike) as specified by ANSI/IEEE Std. C62.41. Upon request, the Manufacturer shall provide the means to demonstrate conformance to this specification using the appropriate surge-generation equipment.
- E. Relays shall be rated for 16 amps continuous duty, for the following load types: resistive (incandescent/tungsten), inductive (magnetic low voltage, neon/cold cathode, magnetic fluorescent lamp ballasts), and capacitive (electronic low voltage, electronic fluorescent lamp ballasts, high intensity discharge). Relays rated only for resistive loads shall not be acceptable.
- F. Load shall be switched in a manner that ensures no arcing will occur at the mechanical contacts when power is applied to the load circuits.
- G. Average rated life of relay shall be at least 1,000,000 cycles.
- H. Assembly shall include diagnostic LEDs to verify proper operation and assist in any system troubleshooting.

2.8 CONTROLS

- A. Definitions: A "scene" or "preset" is a specific look or mood created by different lighting zones set at different intensities. A "zone" is one or more lighting circuits which are controlled together as a group.
- B. Control shall provide power failure memory. Should power be interrupted and subsequently returned, the lights will come back on to the same levels set prior to the power interruption without requiring any actions on the part of the user. Restoration to some other default level is not acceptable, unless specifically noted elsewhere.

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- C. Wiring from dimming and switching panel(s) to centralized preset lighting control and wallstations, preset local lighting controls, and control interfaces shall be low voltage type Class 2 wiring (PELV).
- D. Faceplate shall attach using no visible means of attachment.
- E. Controls shall be engraved with appropriate zone and/or scene descriptions, furnished to the Manufacturer prior to fabrication. Size and style of engraving type shall be determined by the Architect. Any silk-screened borders, logos, graduations, etc., shall use a graphic process that chemically bonds the graphics to the metal faceplate, resisting removal by scratching, cleaning, etc.
- F. Controls shall provide an immediate, local LED response upon button activation to indicate that a system command action has been requested. LED will remain lit contingent upon receiving system confirmation of the successful completion of the command.

2.9 WALLSTATIONS

- A. Wallstations shall have button configurations as required in the drawings. They shall be capable of turning lighting on/off, dimming fixtures, and returning fixtures to a preset lighting level.

2.10 PRESET LOCAL LIGHTING CONTROL(S)—INTEGRAL DIMMERS

- A. Dimmer shall be capable of operating at rated capacity without adversely affecting design lifetime.
- B. Dimmer shall mount individually in standard 2, 3, or 4 gang U.S. wallboxes.
- C. Dimmer shall incorporate an airgap switch that shall be operable without removing the faceplate. The airgap switch shall be capable of meeting applicable requirements of UL 20 and UL 1472 for airgap switches in incandescent dimmers.
- D. Dimmer shall meet IEC 801-2, tested to withstand 15kV electrostatic discharge without damage or loss of memory.
- E. Dimmer shall meet ANSI/IEEE Std. C62.41-1980, tested to withstand voltage surges of up to 6000V and current surges of up to 200A without damage or loss of memory.
- F. Dimmer shall meet the UL 20 limited short circuit test requirement for snap switches.
- G. Dimmer shall compensate for incoming line voltage variations such as changes in RMS voltage, frequency shifts, harmonics and line noise. Dimmer shall be capable of maintaining constant light level with no visible flicker under the following conditions:
 1. $\pm 2\%$ change in RMS voltage/cycle
 2. ± 2 Hz change in frequency/second

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3. Dimmers that do not regulate the dimmer output in real time shall be unacceptable.
- H. Dimmer shall utilize a LC filtering network to minimize interference with properly installed radio, audio, and video equipment.
- I. Separate power booster/interface shall increase dimmer capacity. Capacity shall range from 1000W/VA to 30,000W/VA. Quantities and sizes of each type of power booster/interface shall be provided to control each type of load shown on the load schedule and/or the drawings.
- J. Dimmer shall operate the following sources/load types with a smooth continuous Square Law dimming curve. Dimmers shall also be capable of operating these sources on a full conduction non-dim basis.
 1. Incandescent, Tungsten, Magnetic Low Voltage Transformer
 2. Lutron Tu-Wire Electronic Fluorescent Dimming Ballast
 3. Neon and Cold Cathode
- K. Dimmer shall operate the following sources/load types with a smooth continuous Square Law dimming curve through separate power interfaces.
 1. Electronic Low Voltage Transformer
 2. Fluorescent Electronic Dimming Ballast
- L. Minimum light levels shall be user adjustable in order to compensate for different sources and loading.
- M. Control shall provide four preset lighting scenes and 'off' for up to six (6) control zones. Control shall be capable of storing an additional twelve preset lighting scenes which can be accessed via wallstations and/or control interfaces. Preset shall be set via easy-to-use raise/lower switches, one raise and lower switch per zone. The intensity for each zone shall be indicated via an illuminated bargraph, one (1) bargraph per zone. More than one zone may be proportionately raised or lowered at the same time. Programming of preset scenes shall be accomplished without the use of an 'enter' or 'store' button. Additionally, one or more zones may be temporarily overridden without altering the scene values that are stored in memory.
- N. Lighting levels shall fade smoothly between scenes at time intervals of 0 to 59 seconds or 1 to 60 minutes. The fade time shall be separately selectable for each scene and shall be indicated by a digital display for the current scene. Pressing a scene select button will illuminate the corresponding scene LED and simultaneously begin changing the bargraph levels to reflect the currently selected scene. In the event that a preset scene with a fade time greater than 5 seconds is initially selected from an 'off' condition, the programmed fade time shall be temporarily overridden, unless otherwise noted, and the lights shall fade up to that scene over a five-second time span.
- O. Control shall be capable of being set locally, through a handheld programmer, and/or through a PC.

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- P. Controls shall incorporate built-in wide angle infrared receiver, providing control via a separate wireless remote control transmitter from up to 50 feet away.
- Q. Control shall provide tamperproof protection of scenes using a minimum of four (4) levels of electronic 'lockout' which prevent alterations of scene values stored in memory. Highest level of 'lockout' shall be capable of disabling manual control at the preset control.

2.11 (S)

- A. Contact Closure Interface(s): Control shall provide two-way interface between controls and dry contact closure devices such as from Time Clock Inputs, Building Management Systems, Fire Alarm Systems, Security Systems, and Occupancy Sensors. Control shall provide a minimum of five (5) input and five (5) output terminals. Input terminals must be able to accept maintained or momentary inputs with a minimum pulse time of 40msec. Inputs must have an on-state saturation voltage less than 2.0VDC and an off-state leakage current less than 10mA. Outputs must be capable of controlling other manufacturers' equipment. Customer provided output indicators must not exceed 200mA at 30VDC. Following functions shall be available and shall be set up in software: scene selection, panic mode, occupancy response, sequencing, zone and scene lockouts, and partitioning.
- B. RS232 Interface(s): Control shall provide integration of four (4) scene preset control to user-supplied PC or digital audiovisual equipment using RS232 serial communication. Control provides access to scene selections, scene lockout (prohibits manual light level changes), sequencing, zone lockout (prohibits permanent scene changes), and fine-tuning of light levels with individual zone raise/lower. Control shall provide status monitoring through button feedback and scene-status updates. Control must be mounted within 50 feet (15 meters) of the RS232 source.
- C. DXM512 Interface(s): Control shall be capable of converting thirty-two (32) zone intensities to thirty-two (32) continuous DMX512 outputs.
- D. Room Assignor Control Panel(s): Control shall be capable of accepting up to thirty-two (32) contact closure inputs. Following functions shall be available and shall be set up in software: scene selection, panic mode, occupancy response, sequencing, zone and scene lockouts, and partitioning. Control shall provide a visual status.
- E. Handheld Programmer Jack(s): Control shall provide access to local programming of the lighting control system from hand-held programmers.

2.12 SOURCE QUALITY CONTROL

- A. Equipment shall be 100% tested for proper operation at three (3) different levels - printed circuit board, end of line, and for two (2) hours at 40°C (104°F) ambient - prior to shipment from the factory. Manufacturers sampling at end-of-line shall not be acceptable.

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PART 3 - EXECUTION

3.1 INSTALLATION

- A. Equipment shall be installed utilizing manufacturer's catalogue cut sheets and installation instructions and in accordance with these specifications.
- B. Contractor shall furnish all equipment, labor, system setup and other services necessary for the proper installation of the products/system as indicated on the drawings and specified herein. System setup shall include defining each dimmer's load type, assigning each load to a zone and setting the control functions.
- C. Contractor shall provide an analog phone line to the Centralized Preset Lighting Control Panel to allow remote access for system diagnostics and programming.

3.2 MANUFACTURER'S FIELD SERVICES

- A. Upon completion of the installation, the system shall be completely commissioned by a factory-employed engineer. The check-out will be performed after all loads have been tested live for continuity and freedom from defects and that all control wiring has been connected and checked for proper continuity. The factory-employed engineer shall demonstrate and educate the owner's representative(s) on the system capabilities, operation and maintenance.
- B. Manufacturer shall offer upgraded eight (8) year limited warranty based upon successful field commissioning. The warranty shall have a minimum two (2) year period that covers all parts and labor for repair.
- C. Manufacturer shall provide toll-free technical support hotline twenty-four (24) hours per day, seven (7) days per week.
- D. Manufacturer shall be capable of providing on-site service support within twenty-four (24) hours anywhere in the continental U.S.A., and within seventy-two (72) hours anywhere in the world, except where special visas are required.

END OF SECTION 260943

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SECTION 262200 - TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, "Basic Electrical Materials and Methods", apply to this Section.

1.2 SUMMARY

- A. Furnish and install general purpose and specialty dry type transformers as specified herein and as indicated on the Drawings.

1.3 SUBMITTALS

- A. Provide product data for each type and rating of transformer. Data shall include dimensional plans, sections, and wiring diagrams indicating factory and field wiring.

1.4 QUALITY ASSURANCE

- A. All transformers and the installation of all transformers shall comply with NFPA 70, National Electrical Code, and Maryland Energy Efficiency Standards Act (EESA), enacted into law on March 1, 2005.
- B. Transformers provided under this section shall conform to applicable standards from UL and shall be listed and labeled by UL or a Nationally Recognized Testing Laboratory (NRTL).

PART 2 - PRODUCTS

2.1 DISTRIBUTION TRANSFORMERS

- A. Transformers shall be dry type, air cooled, designed for 60 Hz service, having ratings and characteristics as indicated on the Drawings. Ventilated and non-ventilated transformers shall be provided with UL listed enclosures.
- B. Transformers rated below 30 KVA shall have 365°F (185°C) insulation system and shall be designed for 239°F (115°C) rise above a 104°F (40°C) ambient.
- C. Transformers rated 30 KVA and larger shall have 428°F (220°C) insulation system and shall be designed for 302°F (150°C) rise above a 104°F (40°C) ambient.
- D. Cores shall be fabricated from grain oriented, non-aging silicon steel.

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- E. Coils shall be continuous without splices. Terminations shall be brazed or welded. Shielded transformers shall incorporate an electrostatic shield located between primary and secondary windings.
- F. Core and coil assemblies shall be dried, impregnated with varnish or epoxy, and cured to minimize hot spots and reduce noise.
- G. Transformers rated 30 KVA and larger shall have two (2) above normal full capacity 2-1/2 percent taps and four (4) below normal full capacity 2-1/2 percent taps. Taps shall be readily accessible and shall be set in the field.
- H. Transformers shall be quiet type, which operate at sound levels below ANSI Standard C89-2. Core and coil assemblies shall be mounted on rubber vibration isolators.
- I. Enclosures shall be cleaned and degreased, primed and finished to provide a scratch resistant and weather resistant finish.
- J. Energy Efficiency for Transformers Rated 15 kVA and Larger:
 - 1. Complying with DOE 2016 Efficiency (10 CFR 431).
 - 2. Tested according to NEMA TP 2.

2.2 LOW TEMPERATURE RISE TRANSFORMERS

- A. Low temperature rise transformers shall be furnished and installed where indicated on the Drawings.
- B. Low temperature rise transformers shall conform to the requirements of this Section except as modified herein.
- C. The temperature rise shall not exceed 176°F (80°C) above a 24 hour average ambient temperature of 86°F (30°C) when loaded at the rated KVA.
- D. The transformer shall be capable of providing 30 percent additional capacity continuously without exceeding 302°F (150°C) rise and shall maintain a life expectancy of 20-25 years.
- E. Lower temperature rise shall not be achieved by forced air cooling or by over- ventilating the coil.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Transformers shall be located to provide adequate circulation of cooling air and shall be installed in accordance with the manufacturer's written instructions.
- B. Tighten all connectors and terminations in accordance with the manufacturer's published

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- torque-tightening values.
- C. Transformers shall be grounded in accordance with NFPA 70, National Electrical Code.
 - D. Adjust and set taps to provide optimum voltage for utilization equipment taking into account high and low voltage swings, load changes and voltage drop.
 - E. Provide supports and vibration isolators in accordance with Division-26 section, "Supporting Devices."

END OF SECTION 262200

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SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, Basic Electrical Materials and Methods, apply to this Section.

1.2 SUMMARY

- A. Provide a switchboard in accordance with the plans, elevations, schedules and notes on the Drawings and as specified herein.

1.3 SUBMITTALS

- A. Submit manufacturer's data sheets, wiring schematics and installation dimensional drawings for Owner/Engineer review, comments, and/or approval.
- B. Identify all specified items on submittals to assure compliance and ease of review and/or approval.
- C. Prior to final test and acceptance, submit four (4) complete sets of final data sheets, schematics and dimensional drawings in neat brochure form.
- D. Submittal data required:
 1. Dimensioned plan view of all equipment.
 2. Size and weight of individual shipping units.
 3. Complete diagrams of all control and power connections.
 4. Time - current characteristic curves shall be provided for all overcurrent devices and solid state trip devices. Curves shall be provided on standard 11 x 17 log-log sheets.

1.4 QUALITY ASSURANCE

- A. All work and materials shall conform with the requirements of NFPA 70, "National Electrical Code", the requirements of the local authority having jurisdiction, and where applicable the requirements of IBC.
- B. All materials and assemblies shall be listed and labeled by UL.

PART 2 - PRODUCTS

2.1 SWITCHBOARD

- A. The switchboard shall be dead-front, freestanding front accessible, NEMA 1 indoor construction with the required number of vertical sections to fulfill the requirements for utility metering, a main disconnect, and feeder and branch circuit distribution.
- B. Vertical sections shall be bolted together to form a rigid switchboard. Overall dimensions and shipping splits shall be arranged to comply with the dimensions indicated on the drawings and with the available access to the Electrical Equipment Rooms.
- C. The switchboard shall include all the protective devices with all required accessories, instrumentation, and control devices as indicated on the Drawings and specified herein.
- D. Readily accessible terminal blocks shall be provided for all control wiring leaving the switchboard and for all accessories furnished for customer use.
- E. The sides, top and rear shall be covered with removable screw-on steel plates having formed edges.
- F. The bus shall be silver plated copper of sufficient size and cross-section to limit the temperature rise to 149 degrees F (65 degrees C) based on UL tests. The bus shall be braced for 50,000 amperes RMS symmetrical and supported to withstand the mechanical forces exerted during short-circuit conditions when directly connected to a power source having the specified available short-circuit current.
- G. A full capacity neutral bus shall be provided in all sections. Neutral lugs shall be provided for all four-wire circuits.
- H. A ground bus shall extend the full length of the switchboard and shall be secured in each section. Ground lugs shall be provided for all circuits.
- I. Switchboard shall be provided with adequate lifting means and shall be capable of being rolled or moved into position and bolted directly to the floor without the use of floor sills.
- J. All vertical sections of the switchboard shall be aligned front and rear.
- K. All exterior and interior steel surfaces shall be cleaned and treated with a rust-inhibiting phosphatized coating and then finished with baked enamel conforming to ANSI-61 light gray.
- L. Bus shall be arranged A-B-C left-to-right, top-to-bottom, front-to-rear.
- M. Switchboard ratings shall be based on an ambient temperature of 104 degrees F (40 degrees C).
- N. The main device shall be individually mounted, stationary, completely isolated from the feeder devices. All connections to the main device shall be front accessible.

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- O. The feeder devices shall be group mounted, front accessible.
- P. Switchboard construction shall permit maintenance of incoming line terminations, main device connections, all bus bolted connections and feeder device line and load connections to be performed from the front of the switchboard.
- Q. The main device section shall have a UL service entrance label.
- R. Phenolic nameplates shall be provided for all compartments, sections and circuit protective devices.
- S. Fabricate enclosure with removable, hinged trim for front access to interior of switchboard. Also, provide hinged, rear cover panels where rear access is required.
- T. Provide digital metering complete with all required metering transformers and protective devices to provide the following parameters:

<u>Metered Values</u>	<u>Accuracy</u>
AC Ampere	+ 0.5%
Phase A	
Phase B	
Phase C	
AC Voltage	+ 0.5%
Phase A-B	Phase A
Phase B-C	Phase B
Phase C-A	Phase C
Watts	+ 1.0%
VARS	+ 1.0%
VA	+ 1.0%
Watt-Hours	+ 1.0%
VAR-Hours	+ 1.0%
VA-Hours	+ 1.0%
Power Factor	- 2.0%
Frequency	+ 0.1 HZ
% THD	+ 1.0%

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2.2 CIRCUIT BREAKERS

- A. Unless noted otherwise on the drawings, the main device shall be a 100% rated circuit breaker with stored energy contact operation and ambient insensitive solid state trip device with the following functions:
 - 1. Adjustable pickup and long time delay.
 - 2. Adjustable short-time pickup and delay with I²T function.
 - 3. Adjustable ground fault pickup and delay.
 - 4. Adjustable instantaneous pickup.
 - 5. Trip indicating targets for overload, short circuit, and ground fault.
 - 6. I/C - 42,000 RMS sym. at 480 volts.
- B. Unless noted otherwise on the drawings, the feeder devices shall be molded case circuit breakers of quick-make, quick-break, trip-free thermal magnetic type with frame, trip and voltage ratings, number of poles, and interrupting capacity as indicated on the Drawings and in the schedules. All breakers shall be removable from the front of the switchboard without requiring removal of adjacent units.
- C. The switchboard shall have space or provisions for future units as indicated on the Drawings and in the schedules. Spaces shall include all necessary bus, device mounting supports, and connections requiring only the addition of the circuit breaker.
- D. The main and feeder circuit breakers shall be equipped with suitable lugs as required for the conductors specified on the Drawings.
- E. The main breaker shall be equipped with a bell alarm contact and two (2) normally open and two (2) normally closed auxiliary contacts.

2.3 UTILITY METERING

- A. A utility service entrance section shall be provided to isolate incoming underground service conductors from the remainder of the switchboard.
- B. The service entrance section shall have a metering compartment which shall comply in all respects with the requirements of the utility company.
- C. The metering compartment shall be provided with all lugs, bus, metering transformers, mounting devices and metering devices in accordance with utility specifications.

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PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install switchboards in the locations shown on the Drawings in accordance with manufacturer's written instructions and in accordance with standard accepted practices.
- B. Repair any damage to the enclosure by sanding smooth the damaged area and repainting the entire section. Paint used to repair any enclosure surfaces shall be provided by the manufacturer of the switchboard and shall match the original finish of the switchboard.
- C. Tighten connections and terminations in accordance with manufacturer's published torque tightening values. When manufacturer's values are not established, torque tighten all connections in accordance with UL 486A, UL 486B, and the National Electrical Code.
- D. Refer to drawings for specific installation instructions and requirements.

3.2 GROUNDING

- A. Provide equipment grounding connections for switchboards in accordance with the National Electrical Code and the Drawings.

3.3 TESTING

- A. After installation, check all terminations and connections for tightness and continuity.
- B. Energize the switchboard and demonstrate opening and closing operation of all overcurrent protective devices.
- C. All adjustable circuit breakers and protective relays shall be checked, tested and set by an independent Nationally Recognized Testing Lab (NRTL) in accordance with NETA specifications, the manufacturer's written instructions and Division-26 Section, Inspections, Testing and Start-up".
- D. All protective devices shall be set in accordance with the approved coordination study. Copies of a certified test report shall be provided in accordance with Division-26 Section, "Inspections, Testing and Start-up" of these specifications.

END OF SECTION 262413

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SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, Basic Electrical Materials and Methods, apply to this Section.
- B. Cabinets and enclosures shall conform to Division-26 Section, Boxes, Fittings and Cabinets.

1.2 SUMMARY

- A. Furnish and install panelboards, cabinets and boxes as indicated on the Drawings and as specified herein.

1.3 SUBMITTALS

- A. Provide product data for all panelboards, enclosures, cabinets, overcurrent devices and accessories.
- B. Provide time-current-characteristic curves for all phase overcurrent devices rated 100 amperes or more and for all ground fault protective devices.

1.4 QUALITY ASSURANCE

- A. Panelboards shall be supplied and installed in strict conformance with NFPA 70, National Electrical Code.
- B. Products supplied under this Section shall comply with applicable requirements of UL standards pertaining to panelboards, overcurrent devices, enclosures, and cabinets. Completed assemblies shall be UL listed and labeled.

PART 2 - PRODUCTS

2.1 PANELBOARDS

- A. Panels shall be of the circuit breaker type, and shall have capacity and arrangement as shown on the panel schedules or one-line diagram.
- B. Branch circuit breakers shall be bolt-on type and shall be of the ambient compensated, thermal magnetic type, which will provide inverse time delay overload, and instantaneous short circuit protection. Branch circuit breakers shall have one, two or three poles as

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designated on the panel schedule. No circuit breakers utilizing handle ties for two or three pole operation shall be acceptable. Voltage and current ratings shall be as indicated on the drawings.

- C. Refer to panel schedules on drawings for exact circuit breaker arrangements and interrupting capacities. Provide circuit breakers UL listed as type HACR for air conditioning equipment branch circuits.
- D. Main breakers and branch breakers shall have the same minimum ampere interrupting capacity. Series rating shall not be acceptable.
- E. Provide a typewritten directory for each panel, placed inside the panel door. The directory shall list all rooms served by each breaker, using the "Owner's" room numbers. Directories shall be installed in a metal directory frame under glass or minimum 0.03 (.75 mm) inch thick clear non-yellowing plastic. Spares and spaces shall be written in pencil.
- F. All circuit breakers which serve time clocks, telephone and communication equipment, refrigerators, exit signs, emergency circuits, fire alarm, security, and other miscellaneous control devices shall be equipped with mechanical handle locking devices.
- G. Where panels contain contactors, the contactors shall be mounted behind a hinged, locking door. Contactor section shall be below the circuit breaker section unless otherwise noted. Provide all required barriers. Contactors shall conform to the requirements of Division-26 Section, Disconnects, Switches and Contactors.
- H. Each panel shall be equipped with a ground bus, adequate for feeder and branch circuit equipment grounding conductors; bonded to box.
- I. Each panel and cabinet and the units comprising same shall bear the manufacturer's nameplate and the UL label. Panelboards used for service entrance equipment shall be UL Service Entrance rated/labeled.
- J. All single-phase, three-wire and three-phase, four-wire panels shall be equipped with a fully rated neutral bar. The neutral bar shall be sized to accommodate oversized neutral conductors where oversized neutral conductors are indicated on the Drawings.
- K. All bus shall be copper.
- L. Cabinet and trim shall be of code gauge steel (minimum) with 4" (100 mm) (minimum) wiring gutter all around. All panelboards shall be equipped with a hinged, locking door and hinged trim. Two (2) keys shall be furnished with each cabinet, and all locks on all cabinets shall be keyed alike. Provide door-in-door panel cover.
- M. Where panels occur adjacent to one another in finished spaces, cabinets and doors for each panel shall be of the same height.
- N. Panelboards shall be painted with gray over rust preventive primer.

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PART 3 - EXECUTION

3.1 INSTALLATION

- A. Mount panels in locations shown, making sure that code-required clearances exist.
- B. Where cabinets cannot be set fully flush due to shallowness of partition, trim protruding sides with approved metal or hardwood molding, fastened to cabinet so as to conceal intersection of wall and cabinet.
- C. If paint is damaged during shipping or installation, damaged portion shall be sanded smooth and entire panel repainted.
- D. Provide five (5) spare 3/4" (19 mm) conduits stubbed into accessible ceiling spaces above and below each flush mounted panel.
- E. Load Balancing: After substantial completion, but not more than 60 days after final acceptance, measure load balancing and make circuit changes.
 - 1. Measure loads during periods of normal system loading (coordinate with Owner).
 - 2. Perform load balancing circuit changes outside normal occupancy/working schedule of the Owner at time directed by Owner's representative.
 - 3. After circuit changes are completed, recheck loads during normal load period. Record all load readings before and after changes and submit test results.
 - 4. Tolerance: Difference exceeding 20 percent between phases within a panelboard is not acceptable. Rebalance and recheck as necessary to meet this requirement.

END OF SECTION 262416

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SECTION 262413 – GENERATOR DOCKING STATION WITH CIRCUIT BREAKER

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, Basic Electrical Materials and Methods, apply to this Section.

1.2 SUMMARY

- A. Provide equipment for docking a temporary generator and connecting to electrical distribution equipment in accordance with the plans, elevations, schedules and notes on the Drawings and as specified herein.

1.3 SUBMITTALS

- A. Submit manufacturer's data sheets, wiring schematics and installation dimensional drawings for Owner/Engineer review, comments, and/or approval.
- B. Identify all specified items on submittals to assure compliance and ease of review and/or approval.
- C. Prior to final test and acceptance, submit four (4) complete sets of final data sheets, schematics and dimensional drawings in neat brochure form.
- D. Submittal data required:
 1. Dimensioned plan view of all equipment.
 2. Size and weight of individual shipping units.
 3. Complete diagrams of all control and power connections.
 4. Time - current characteristic curves shall be provided for all overcurrent devices and solid state trip devices. Curves shall be provided on standard 11 x 17 log-log sheets.

1.4 QUALITY ASSURANCE

- A. All work and materials shall conform with the requirements of NFPA 70, "National Electrical Code", the requirements of the local authority having jurisdiction, and where applicable the requirements of BOCA.
- B. All materials and assemblies shall be listed and labeled by UL.

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PART 2 - PRODUCTS

2.1 GENERATOR DOCKING STATION

A. Manufacturers: Basis of design shall be:

1. TRYSTAR Product Family: GDS

2.2 GENERAL REQUIREMENTS

A. Enclosures

1. Base-mounted cabinet.
2. Front accessible for maintenance.
3. Front accessible for connection of temporary cabling.
4. Rated for environmental conditions at installed location:
 - a. Outdoor locations: NEMA 250, Type 3R.
5. .100" Aluminum front cover:
 - a. Hinged.
 - b. Gasketed.
 - c. Pad-lockable latch.
6. Finishes:
 - a. Paint after fabrication. Powder coated Hammer Gray.

B. Phase, Neutral and Ground Buses

1. Material: Silver-plated hard-drawn copper.
2. Equipment Ground Bus: bonded to box.
3. Ground Bus: 100% of phase size.
4. Neutral Bus: 100% of phase bus.
5. Round edges on bus.

C. Bus Connectors:

1. Located behind access plate inside front cover.

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2. Lugs.
- D. Input Connectors:
 1. Located inside front cover: Cam style.
- E. Hinged cable access door on bottom of unit.
- F. Voltage & Phase: 277/480V – 3 phase – 4 wire
- G. Amperage: Per the plans.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install generator docking station in the location shown on the Drawings in accordance with manufacturer's written instructions and in accordance with standard accepted practices.
- B. Repair any damage to the enclosure by sanding smooth the damaged area and repainting the entire section. Paint used to repair any enclosure surfaces shall be provided by the manufacturer of the switchboard and shall match the original finish of the equipment.
- C. Tighten connections and terminations in accordance with manufacturer's published torque tightening values. When manufacturer's values are not established, torque tighten all connections in accordance with UL 486A, UL 486B, and the National Electrical Code.
- D. Install Generator Docking Station on concrete bases, 4-inch (100-mm) nominal thickness.
 1. For Generator Docking Station, install epoxy-coated anchor bolts that extend through concrete base and anchor into concrete slab.
 2. Place and secure anchorage devices. Use setting, drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 3. Install anchor bolts to elevations required for proper attachment to Generator Docking Station.

3.2 GROUNDING

- A. Provide equipment grounding connections for generator docking stations in accordance with the National Electrical Code and the Drawings.

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3.3 TESTING

- A. After installation, check all terminations and connections for tightness and continuity.
- B. Energize the docking station and demonstrate opening and closing operation of all overcurrent protective devices.
- C. All adjustable circuit breakers and protective relays shall be checked, tested and set by an independent Nationally Recognized Testing Lab (NRTL) in accordance with NETA specifications, the manufacturer's written instructions and Division-26 Section, Inspections, Testing and Start-up".
- D. All protective devices shall be set in accordance with the approved coordination study. Copies of a certified test report shall be provided in accordance with Division-26 Section, "Inspections, Testing and Start-up" of these specifications.

END OF SECTION 262413

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SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, "Basic Electrical Materials and Methods", apply to this Section.
- B. The requirements for outlet boxes and device enclosures are provided in Division-26 Section, "Boxes, Fittings and Cabinets".

1.2 SUMMARY

- A. The Contractor shall furnish and install all wiring devices indicated on the Drawings or specified herein.

1.3 SUBMITTALS

- A. Provide product data for each type of wiring device specified.

1.4 QUALITY ASSURANCE

- A. All products and the installation of all products shall comply with NFPA 70, "National Electrical Code."
- B. Wiring devices shall be listed and labeled by UL and shall confirm to the latest UL and NEMA standards pertaining to wiring devices.

PART 2 - PRODUCTS

2.1 WIRING DEVICES

- A. All wiring devices shall be Specification Grade.
- B. Wiring devices shall be white in color unless otherwise indicated.
- C. Convenience receptacles shall be duplex, grounding type, 20A, 2P, 3W, 125V, NEMA 5-20R, straight blade, nylon or high-strength thermoplastic material.
- D. Safety receptacles (tamper-resistant) shall be flush, specification grade, grounding type, 20A, 2P, 3W, 125VAC, NEMA 5-20R, straight blade, nylon or high-strength thermoplastic material unless indicated as special purpose outlet. Receptacles shall be designed to accept standard two-wire parallel connector caps and shall grip both sides of the

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- connector wire. Receptacles shall utilize dual shutter system to prevent insertion of foreign objects.
- E. Unless provided with a GFCI circuit breaker, convenience receptacles serving bathrooms, toilets, outdoor and wet locations, and construction sites shall be of the ground fault interrupter type, duplex, grounding type, 20A, 2P, 3W, 125V, NEMA 5-20R, straight blade, nylon or high-strength thermoplastic material.
 - F. Convenience receptacles located in wet locations shall be of the ground fault interrupter, weather resistant type, duplex, grounding type, 20A, 2P, 3W, 125V, NEMA 5-20R, straight blade, nylon or high-strength thermoplastic, corrosion resistant material.
 - G. Automatically controlled receptacles shall be labeled as required by NEC article 406.3 (E).
 - H. Clock receptacles shall be single, grounding and hanger type, 15A, 2P, 3W, 125V, NEMA 5-15R, straight blade, nylon or high-strength thermoplastic material with stainless steel plate.
 - I. Single throw toggle switches shall be quiet type rated 20A, 1P, 120/277 VAC.
 - J. Single throw lighted toggle switches shall be quiet type rated 20A, 1P, 120/277 VAC, illuminated red polycarbonate handle. Handle shall glow when switch is on.
 - K. Unless provided as part of a low voltage lighting control system, key operated light switches shall be rated 20A, 1P, 120/277 VAC, gray toggle cover, with two (2) keys furnished for each switch. All switches shall operate from the same key.
 - L. Three-way toggle switches shall be quiet type rated 20A, 120/277 VAC. Switches shall be positive-action type and shall not permit a maintained neutral position.
 - M. Four-way toggle switches shall be quiet type 20A, 120/277 VAC. Switches shall be positive-action type and shall not permit a maintained neutral position.
 - N. Photo control relays shall be as specified in Division-26 Section, Lighting Fixtures.
 - O. Wall plates for switches, receptacles, etc. in indoor dry areas, shall be satin finish stainless steel Type 302 for concealed raceways; and zinc-coated sheet steel or cast metal having round or beveled edges, for exposed raceways. Install galvanized steel wallplates in unfinished spaces.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install wiring devices and accessories as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices to fulfill project requirements.

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- B. Coordinate with other work, including painting and installation of electrical boxes and wiring.
- C. Install wiring devices only in electrical boxes which are clean; free from building materials, dirt, and debris.
- D. Install wiring devices after wiring work is completed.
- E. Install wallplates after painting work is completed.
- F. Install telephone/power service poles in accordance with final furnishing arrangement plan, plumb, true, and secure.
- G. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 486A. Use properly scaled torque indicating hand tool.
- H. Protect installed components from damage. Replace damaged items prior to final acceptance.
- I. Provide weatherproof, in-use covers for all receptacles located in wet locations per NEC 406.9(B).

3.2 TESTING

- A. Prior to energizing circuits, test wiring for electrical continuity and short-circuits. Ensure proper polarity of connections is maintained. Subsequent to energizing, test wiring devices and demonstrate compliance with requirements, operating each operable device at least six (6) times.
- B. Test ground fault interrupter operation with both local and remote fault simulations in accordance with manufacturer recommendations.

END OF SECTION 262726

SECTION 262736 - ELECTRICAL CONNECTIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, "Basic Electrical Materials and Methods", apply to this Section.

1.2 SUMMARY

- A. The Contractor shall provide electrical connections to and between all equipment indicated on the Drawings and Schedules and in the Specifications.
- B. Electrical connections shall be provided for, but not limited to, electrical heaters; lighting fixtures; motors; motor starters and controllers; electrical distribution equipment; converters, rectifiers, transformers, and inverters; and communication, computer, clock, intercom, telephone, security, fire alarm and video systems.
- C. Unless otherwise specified, the Contractor shall, under this Section, mount and align all starters, control devices, safety switches and other related equipment whether specified in this or other Sections of the specifications, except where such items are factory mounted on the driven equipment. The mounting and alignment of starters and control devices for the automatic temperature control system are included in the Sections in which the equipment is specified.
- D. Unless otherwise specified, the Contractor shall, under this Section of the specifications, provide all wiring, including conduit, wire, junction boxes, disconnecting switches, overcurrent protection, etc., not specified elsewhere in this specification, to and between all motors, starters, control devices and related electrical equipment, whether specified in this or other Sections of this specification, except where such items are factory wired, as well as factory mounted on the driven equipment.
- E. Wiring for the automatic temperature control system is specified in other Sections of the specification.
- F. Unless otherwise specified, all wiring to motors, control equipment and related electrical equipment, shall be installed in conduits with flexible metal conduit connections utilized for final motor connections. Flexible conduits shall be large enough to accommodate motor feeder, ground conductors and control wires, whether or not so indicated on the drawings. Flexible conduits shall be limited to a maximum length of 6'-0" (1800 mm-0 mm).
- G. The drawings are diagrammatic. It is imperative that the contractor obtain exact rough-in information for all equipment well in advance of actual installation to provide coordination for his and other trades.

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1.3 SUBMITTALS

- A. Submit product data for all materials and components used for electrical connections.

1.4 QUALITY ASSURANCE

- A. All materials and components and the installation of all materials and components shall comply with the requirements of the following standards:

1. NFPA 70 "National Electrical Code"
2. IEEE Standard 241 "IEEE Recommended Practice for Electric Power Systems in Commercial Buildings"
3. Applicable standards of ANSI/IEEE and NEMA pertaining to the products and installation of products for electrical connections
4. UL Standard 486A "Wire Connectors and Soldering Lugs for Use with Copper Conductors"

- B. All materials and components shall be listed and labeled by UL or ETL.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Provide all materials and components required for complete splices and terminations of all circuits. All wiring shall be spliced and terminated using lugs and/or terminal blocks, except as permitted elsewhere in these Specifications.
- B. All splices in branch circuit wiring rated 600 volts and less, except as permitted elsewhere in these Specifications, shall be made using compression type lugs specifically designed for the type, size and rating of the conductor. The lugs shall be installed using a tool specifically designed for the purpose.
- C. Splices in copper branch circuit wiring for sizes #12 and #10 AWG may be made with non-tool, pre-insulated, molded wire connectors with integral self-locking spring grip.
- D. All terminations of feeders and branch circuit wiring rated 600 volts or less, except as noted elsewhere in these specifications, shall be made using mechanical clamp-type set-screw lugs. Lugs which incorporate direct contact between the set-screw and the conductor shall not be permitted.
- E. Tapes:
1. Self-adhesive tapes shall be used to insulate conductor splices. Terminations shall be in conformance with the following standards:

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- a. 600 Volts, Nominal and Less: UL 510, ASTM D-2754, ASTM D-3005, and ASTM D-4388.
 - b. 600 Volts through 69 Kilo Volts: ASTM D-4388 and IEEE 48.
2. Vinyl plastic electrical tape shall be used for all terminations and splices of conductors for circuits of 600 volts nominal and less, except terminations in motor terminal boxes, transformer terminations, lighting and all heat producing equipment terminations. Terminations of the equipment listed herein shall be insulated with pressure sensitive glass cloth tape.
 3. Ethylene propylene rubber (EPR) high voltage insulating tapes with liner shall be used for all splices and terminations over 600 volts nominal. The tapes shall be included a standard component of the manufacturer's compiled high voltage splice termination kits. All splices and terminations of 5 kV and 15 kV cables shall be accomplished with high voltage splice and termination kits only.
 4. Tapes and high voltage splice and termination kits shall be the standard product of 3M Corporation, Plymouth Rubber Company, Inc. or approved equivalent.
- F. Special lugs may be required to accommodate the size and number of conductors shown on the Drawings. The Contractor shall verify lug requirements for all circuit breakers and equipment terminals and shall provide correct lugs as required.
- G. Pre-insulated solderless ring or spade type crimp connectors and terminals shall be used for all alarm and control circuits.
- H. All connectors and terminals shall be of the proper size and ampacity, material and type for the application and service.

2.2 RACEWAYS AND FITTINGS

- A. The Contractor shall provide raceways and fittings of the types, sizes, and finish indicated for each type of service. Where the type of raceway is not specified, the Contractor shall provide and install a raceway of proper selection as determined by the installer to fulfill the wiring and equipment connection requirements and comply with NEC requirements for raceways.
- B. All raceways and fittings and the installation of all raceways and fittings shall comply with the requirements of these Specifications.

PART 3 - EXECUTION

3.1 INSPECTION

- A. The Contractor shall inspect the area where electrical connections are to be installed. The installation of electrical connections shall not be permitted until site conditions are satisfactory.

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3.2 INSTALLATION

- A. The Contractor shall install all electrical connections in accordance with the manufacturer's written instructions using recognized industry practices.
- B. Power, control, data, signal and communication circuits shall be connected to equipment in accordance with the manufacturer's wiring diagrams. The Contractor shall be fully responsible for the correct termination and interface of all electrical connections.
- C. Splices shall be insulated with tape which provides an insulation rating which meets or exceeds the insulation rating of the conductor. All outdoor splices shall be made watertight using tapes and sealants specifically designed and listed for outdoor applications.
- D. Wiring devices shall not be used as splices.
- E. Electrical connections shall be tightened in accordance with equipment manufacturer's published torque tightening values. The installer shall use proper tools which shall include torque screwdriver, torque wrench, and ratchet wrench with adjustable torque settings.
- F. UL Standard 486A torque tightening values shall be used when manufacturer's published tightening values are not available.

3.3 TESTING

- A. All electrical connections shall be tested to ensure electrical continuity and compliance with these Specifications.
- B. The Contractor shall demonstrate to the Owner or Engineer that a random selection of electrical connections has been tightened in accordance with the manufacturer's published torque tightening values.

END OF SECTION 262736

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SECTION 262816 - DISCONNECTS, SWITCHES AND CONTACTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, "Basic Electrical Materials and Methods", apply to this Section.

1.2 SUMMARY

- A. The Contractor shall furnish and install circuit and motor disconnect switches, remote control switches and magnetic contactors where indicated on the Drawings and where required by the National Electrical Code, local codes and the authority having jurisdiction.

1.3 SUBMITTALS

- A. Provide product data for each type and rating of circuit and motor disconnect switch.

1.4 QUALITY ASSURANCE

- A. Circuit disconnects and motor disconnect switches and the installation of same shall comply with the requirements of NFPA 70, "National Electrical Code."
- B. Circuit and motor disconnect switches shall be listed and labeled by UL.

PART 2 - PRODUCTS

2.1 CIRCUIT AND MOTOR DISCONNECT SWITCHES

- A. Switches shall be constructed in accordance with the latest editions and revisions of NEMA Standard KS-1, Federal Specification W-S-685C, and Underwriters' Laboratories Standard 98.
- B. Switches shall be fusible or non-fusible as indicated on the Drawings, or as required by the equipment served, horse-power rated, quick-make, quick-break, heavy-duty type with integral arc suppressors. The handle shall be part of the enclosure, not the cover.
- C. Fused switches and fuses shall have a minimum integrated interrupting rating of 100,000 amperes RMS symmetrical.
- D. Switches 800 amperes and larger shall be bolted pressure type.
- E. Switches used for service entrance shall be service rated and bear the U.L. service

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- entrance label.
- F. Switches shall have general purpose surface mounted NEMA type 1 or 3R enclosures as indicated or required by locations. All enclosures shall be designed to permit padlocking in the "open/off" position.
 - G. Switches on 120/208 volt service shall be rated 240 volts and switches on 277/480 volt service shall be rated 600 volts.
 - H. Fused switches for motor applications shall be furnished with UL listed dual-element Class RK-1 time delay fuses rated 600 volts. Fuse current ratings shall be as indicated on the Drawings or in accordance with the motor manufacturer's recommendations when specific sizes are not specified on the Drawings.

2.2 REMOTE CONTROL SWITCHES

- A. Remote control switches shall be electrically operated, mechanically held. The main contacts shall be power driven to both the open and closed positions. Operating mechanisms which rely on gravity or permanent magnets shall not be used.
- B. The contacts and operating mechanism shall be enclosed by an insulated cover. A safe manual operator shall be provided to either open or close the switch.
- C. The main contacts shall be silver alloy composition and shall be protected by arcing contacts on sizes 600 amperes and above. Auxiliary contacts shall be rated 10A, 120 VAC. Provide one normally open and one normally closed auxiliary contact.
- D. Contacts, power and control connections, coils, and arc chutes shall be accessible and serviceable from the front.
- E. The remote control switches shall be rated in amperes for a total system load including motors, lighting ballasts, and resistive and tungsten filament lamp loads.
- F. Remote control switches shall be individually enclosed or panelboard mounted as indicated on the drawings. Enclosures shall comply with the requirements of Division-26 Section, "Boxes, Fittings and Cabinets."
- G. Remote control switches shall have a UL listed withstand current rating equal to or exceeding the available short-circuit current at the location where the switch is to be installed.
- H. The remote control switch shall be arranged for two-wire control from a maintained type control switch. All controls and modules, with the exception of the control switch, shall be located in the same enclosure with the remote control switch.

2.3 MAGNETIC CONTACTORS

- A. Magnetic contactors shall be electrically operated, mechanically held.

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- B. The contacts and operating mechanism shall be enclosed by an insulated cover.
- C. The main contacts shall be silver alloy composition and shall be protected by arcing contacts on sizes 600 amperes and above. Auxiliary contacts shall be rated 10A, 120 VAC. Provide one normally open and one normally closed auxiliary contact.
- D. Contacts, power and control connections, coils, and arc chutes shall be accessible and serviceable from the front.
- E. Contactors shall be rated in amperes for a total system load including motors, lighting ballasts, and resistive and tungsten filament lamp loads.
- F. Contactors shall be individually enclosed or panelboard mounted as indicated on the Drawings. Enclosures shall comply with the requirements of Division-26 Section, "Boxes, Fittings and Cabinets."
- G. Contactors shall have a UL listed withstand current rating equal to or exceeding the available short-circuit current at the location where the switch is to be installed.
- H. The contactor shall be arranged for two-wire control. All controls and modules, with the exception of control switches, push buttons and pilot lights shall be located in the same enclosure with the contactor.

2.4 CONTROLS

- A. Push buttons shall be momentary contact, heavy duty, oiltight with legend plate. Buttons shall be fully guarded and shall be red in color.
- B. Selector switches shall be two position, heavy duty, oiltight with legend plate.
- C. Contact blocks shall be provided as required for all push buttons and switches. Contacts shall have a 10 ampere continuous current rating at 120 VAC or 120 VDC except where indicated otherwise.
- D. Pilot lights shall be heavy duty, oiltight with legend plate. Pilot lights shall utilize incandescent lamps designed for high brightness applications. Lens shall be acrylic fresnel type of the color specified.
- E. Control stations shall be recessed with sufficient space to accommodate operators as required. Provide stainless steel NEMA 1 flush cover plates.
- F. Boiler emergency stop switches shall be guarded, red toggle-type, single pole, rated 30 amperes at 250 VAC. Switch shall be enclosed in a single gang outlet box with red coverplate and legend to read "EMERGENCY STOP". A nameplate shall be provided to indicate the equipment served. The electrical contractor shall route 3/4" conduit and control wires from each switch to boiler control panel. Coordinate wiring type and quantity with boiler manufacturer. Leave six (6) feet of slack within boiler control panel for final termination by ATC contractor. Coordinate connection point in boiler control panel with boiler manufacturer.

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2.5 ACCESSORIES

- A. Provide electrical interlocks where indicated on the Drawings.
- B. Provide one normally open and one normally closed auxiliary contact on each switch. Auxiliary contacts shall be rated 10A, 120 VAC.
- C. Fused disconnects and switches shall be provided with integral built-in fuse pullers arranged to facilitate fuse removal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Switches shall be coordinated with the equipment to provide switches to suit the particular equipment characteristics and requirements.
- B. Provide fusible switches for all equipment labeled for and/or requiring fuse protection.
- C. Switches shall be installed in accordance with manufacturer's published instructions.
- D. Provide three (3) spare fuses of each type and rating furnished for this project. Deliver spare fuses to the Owner's place of storage.

3.2 TESTING

- A. Prior to energizing circuits and switches, test wiring for electrical continuity and short-circuits.

END OF SECTION 262816

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SECTION 262817 - ENCLOSED CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes molded-case circuit breakers in individual enclosures.

1.2 REFERENCES

- A. National Electrical Manufacturers Association:
 - 1. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches

1.3 SUBMITTALS

- A. Division-01 Section - Submittal Procedures: Submittal procedures.
- B. Product Data: Submit catalog sheets showing ratings, trip units, time current curves, dimensions, and enclosure details.

PART 2 - PRODUCTS

2.1 MOLDED CASE CIRCUIT BREAKER

- A. Product Description: Enclosed, molded-case circuit breaker conforming to NEMA AB 1 with interrupting capacity to comply with available fault currents [, and suitable for use as service entrance equipment where applied].
- B. Accessories: As indicated on Drawings. Conform to NEMA AB 1.
- C. Enclosed circuit breakers shall have general purpose, surface mounted, NEMA Type 1 or 3R enclosure as indicated or required by location.
- D. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit breaker frame sizes 250 A and larger.
- E. Service Entrance: Enclosed circuit breakers identified for use as service equipment are to be labeled for this application. Furnish solid neutral assembly and equipment ground bar.
- F. Circuit breakers shall be fully rated. Series rated withstand are prohibited.

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PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install enclosed circuit breakers plumb. Provide supports in accordance with Division-26 Section, "Supporting Devices."
- B. Height: 5 feet (1500 mm) to operating handle.
- C. Locate and install engraved plastic nameplates in accordance with Division-26 Section, "Basic Electrical Materials and Methods."

3.2 FIELD QUALITY CONTROL

- A. Inspect and test in accordance with National Electrical Testing Association (NETA).

END OF SECTION 262817

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SECTION 262913 - MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, Basic Electrical Materials and Methods, apply to this Section.

1.2 SUMMARY

- A. Furnish and install motor controllers where indicated on the Drawings, where required by the Contract Specifications, and where required for the control and protection of motors as necessary for a complete installation.
- B. The variable frequency drive (VFD) manufacturer shall supply the drive and all necessary options as herein specified. The manufacturer shall have been engaged in the production of this type of equipment for a minimum of twenty years. VFDs that are manufactured by a third party and "brand labeled" shall not be acceptable. Drive manufacturers who do not build their own power boards and assemblies, or do not have full control of the power board manufacturing and quality control, shall be considered as a "brand labeled" drive. All VFDs installed on this project shall be from the same manufacturer.

1.3 SUBMITTALS

- A. Submit shop drawings and product data for all motor controllers and motor control centers.
- B. Submittals shall include equipment dimensions, power and control wiring diagrams, component descriptions, calculations where required and ratings, and a list of recommended spare parts.
- C. Complete operating and maintenance manuals shall be provided which include technical data sheets, wiring diagrams and information for ordering replacement parts.
- D. The manufacturer shall submit a copy of the specifications with each sub-paragraph noted with the term, "compliance", "deviation", or "alternate".
 1. By noting the term "compliance" it shall be understood that the manufacturer is in full compliance with the item specified and will provide exactly the same with no deviations.
 2. By noting the term "deviation" it shall be understood that the manufacturer prefers to provide a different component in lieu of that specified. Manufacturer shall indicate all deviations.
 3. By noting the term "alternate" it shall be understood that the manufacturer

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proposes to provide the same operating function but prefers to do it in a different manner. Any alternate shall be fully described as to what the manufacturer proposes to provide.

- E. Harmonic Conditioning and Line Filtering: Submit a detailed description and product data for the harmonic filtration mitigation devices provided for each VFD installed for this project. Harmonic filtering shall be provided as indicated on the drawings and in this specification.
- F. Variable Frequency Drive (VFD) submittals shall be submitted under separate, stand-alone submittal package when VFD is provided by Division-23 as part of mechanical equipment.

1.4 QUALITY ASSURANCE

- A. Motor controller components and assemblies shall be furnished and installed in accordance with NFPA 70, National Electrical Code, and shall conform to the requirements of UL 845 and applicable sections of NEMA and ANSI/IEEE standards.
- B. Motor controllers and motor control centers shall be listed and labeled by Underwriters' Laboratories or a Nationally Recognized Testing Laboratory (NRTL).
- C. Source Limitations: Obtain Motor Controllers through one source from a single manufacturer.
- D. VFDs and options shall be UL508 listed as a complete assembly. The base VFD shall be UL listed for 100 kA SCCR without the need for external input fuses.

PART 2 - PRODUCTS

2.1 FRACTIONAL HORSEPOWER STARTERS

- A. Fractional horsepower manual starters shall be used for single phase motors except where indicated. Single phase starters shall provide across the line starting and overload protection. Single pole and double pole starters shall be used as required and shall be rated not less than 1 horsepower.
- B. Single phase manual starters shall feature snap action double-break contacts, motor running indicating light and trip free melting alloy overload elements selected for the specific motor application.
- C. Single phase manual starters located in mechanical and electrical rooms shall be installed in NEMA 1 general purpose enclosures. Starters located outdoors or in wet locations shall be installed in NEMA 4 watertight enclosures. Starters located in finished areas shall be installed in a flush outlet box and furnished with a stainless steel plate.
- D. Manual motor starters shall be toggle-type and shall be arranged so they may be locked with a padlock in the OFF position.

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2.2 COMBINATION STARTERS

- A. Combination motor starters shall be provided with an integral motor circuit protector specifically designed for motor applications. The MCP shall have a continuous current rating in accordance with NEC Article 430 and shall provide adjustable short-circuit trip settings. The MCP shall have a minimum short-circuit rating of 42,000 amperes at 480 volts.
- B. An external operating handle for the MCP shall be provided. The handle shall clearly indicate the position of the MCP and shall be padlockable in the OFF or OPEN position. Interlocks shall be provided to prevent opening the door when the external operating handle is in the ON or CLOSED position. An interlock defeater shall be provided for use by authorized personnel.
- C. Magnetic-type motor starters shall be used for single phase motors where indicated and for all three phase motors.
- D. Starters shall be full voltage non-reversing (FVNR) or reduced voltage type as indicated on the Drawings. Starters shall utilize three temperature compensated bimetallic overload relays factory set for the specific motor application. Overload relays shall be field adjustable plus or minus 15 percent of the rated trip current. Solid state overload relays are acceptable.
- E. Starters shall be furnished with the following accessories:
 - 1. Hand-off-auto selector switch.
 - 2. Green pilot light to indicate power available to the starter but motor not on.
 - 3. Red pilot light to indicate motor running.
 - 4. Transformer for 120 volt control power (fused primary and secondary).
 - 5. Overload trip indicator and reset.
 - 6. Undervoltage monitor and release.
 - 7. Coils rated 120 volts A.C.
 - 8. Two (2) normally open and two (2) normally closed auxiliary contacts for customer use.
- F. Reduced Voltage Starter:
 - 1. Solid state starters shall be provided with Class 20 electronic overload and phase loss, current unbalance, undervoltage and overtemperature protection.
- G. Starters shall be capable of withstanding the let-through short-circuit current of the protective device. Current limiters shall be provided when required to achieve adequate protection from high short-circuit currents.

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- H. Where the Drawings indicate individual enclosures for starters, the starters shall be provided in NEMA type 1 enclosures except when noted otherwise on the Drawings. Outdoor starters shall be in NEMA 3R enclosures.
- I. Starters to be installed in motor control centers shall conform to these specifications and the section pertaining to motor control centers.

2.3 VARIABLE FREQUENCY DRIVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary; Basis of Design: ACH580 with E-Clipse Bypass when bypass is required.
 2. Yaskawa Electric America, Inc.
 3. Danfoss, Inc.; Danfoss Electronic Drives Division
 4. Toshiba International Corporation
- B. Variable Frequency Drives (VFD) shall be of a Pulse Width Modulated (PWM) design with an input power factor greater than 0.95 at all operating speeds and loads. The VFD shall have an efficiency of 96% or greater at rated output.
- C. The VFD shall be microprocessor based and utilize digital input for parameter adjustments. Use of potentiometers for parameter adjustment is not acceptable.
- D. The VFD shall automatically attempt to restart after a malfunction or an interruption of power. The number of attempted restarts shall be customer selectable (0 to 5). If the drive reaches the limit of restarts without successfully restarting and running, restart circuit shall lockout.
- E. A current limit circuit shall be provided to limit motor current to a preset adjustable maximum level by reducing the drive operating speed or acceleration rate when the limit is reached. Range of adjustment shall be from 50 to 110% of controller rated output.
- F. The VFD shall include a digital display and digital input programming capability. The display shall be programmable for indication of output speed in rpm, frequency or percent of base speed; motor current (amperes) and output motor voltage. The display shall also function as a first fault indicator.
- G. Upon receipt of N.O. "dry" contact closure, the VFD shall run at a preset (field adjustable) speed.
- H. The VFD shall provide selection for Hand-Off-Auto control. In Hand mode, the motor shall be started and stopped from the operator's panel. In the Auto mode, the motor shall be started and stopped by remote contact closure. In the Off mode, the motor shall be locked out. The Hand-Off-Auto control shall operate in both the VFD mode and the bypass mode (if bypass is provided).

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- I. The VFD shall provide selection for Manual ref/Auto ref. In the Man ref. mode, the VFD speed reference shall be set from the operators panel. In the Auto ref. mode, the VFD speed reference shall be set by the external source instrument signal.
- J. The input signal follower circuit shall have selectable differential inputs and accept an electrical speed command from an external source rated at 4-20 mA or voltage signals of 0-10 Vdc.
- K. Electronic motor protection shall be provided. The protection circuit shall provide orderly shutdown.
- L. The VFD shall include a programmable 4-20 ma analog output which shall be capable of indicating output frequency, motor speed, output current, motor torque, motor power or motor voltage. The VFD shall include a minimum of two programmable digital outputs (form C relay contacts) capable of indicating drive run, drive fault, and drive ready. The VFD shall include an interface chip to provide open protocol capability for interface with the Energy Management/ATC system. Coordinate protocol with Energy Management/ATC manufacturer.
- M. The VFD stopping mode functions shall be selectable for coast to rest or stopping at programmed deceleration rate.
- N. In the event of loss of input follower reference signal (transducer failure), the VFD shall go to a preset speed which shall be user adjustable. The VFD shall provide a digital output signal (form C relay contact) to indicate the loss of reference condition.
- O. The input current rating of the VFD shall not be greater than the output current rating. VFDs with higher input current ratings require the upstream wiring, protection devices, and source transformers to be oversized per NEC 430.122. Input and output current ratings must be shown on the VFD nameplate.
- P. The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and reduce audible motor noise. The VFD shall have selectable software for optimization of motor noise, energy consumption, and motor speed control.
- Q. The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows higher carrier frequency settings without derating the VFD.
- R. The VFD shall include password protection against parameter changes.
- S. The VFD shall operate within the following ratings and provide the following characteristics:
 - 1. Output frequency range: 1-120 Hz.
 - 2. Frequency resolution: 0.5% of base speed with analog input 0.025% with digital input.
 - 3. Overload rating: 110% for one minute.

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4. Voltage Tolerance:
 - a. The VFD shall provide full rated output from an input voltage of 480 V +/- 10% or 208V +/- 10%. Coordinate with motors specified.
 - b. The VFD shall continue to operate without faulting from an input voltage of +30% to -35% of nominal voltage.
 5. Minimum speed: 0 to 70%.
 6. Maximum speed: 30 to 120%.
 7. Linear accel: 1 to 300 seconds, time adjustable.
 8. Linear decel: 1 to 300 seconds, time adjustable.
 9. Maximum output voltage: adjustable.
 10. Adjustable V/Hz with selectable profiles.
 11. Operating temperature: 32 degrees F to 104 degrees F (0 degrees C to 40 degrees C).
 12. Altitude: 3300 feet (1000 m).
 13. Humidity: 95% non-condensing.
 14. Minimum three frequency avoidance bands, field selectable.
- T. Bypass: Where indicated on the contract documents, provide single enclosure containing a variable frequency drive and bypass system. All VFD with bypass configurations shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.
1. A complete factory wired and tested bypass system consisting of a door interlocked, padlockable circuit breaker (defeatable), output contactor, bypass contactor, service (isolation) switch and fast acting VFD input fuses. UL Listed motor overload protection shall be provided in both drive and bypass modes. Bypass designs, which have no VFD only fuses, or that incorporate fuses common to both the VFD and the Bypass will not be accepted. The door interlocked, padlockable circuit breaker must disconnect all input power from the drive and all internally mounted options.
 2. The bypass enclosure door and VFD enclosure must be mechanically interlocked such that the disconnecting device must be in the "Off" position before either enclosure may be accessed. The interlock must be defeatable for maintenance activities.
 3. The VFD and bypass package shall have a UL listed short circuit current rating (SCCR) of 100,000 Amps and this rating shall be indicated on the UL data label.
 4. Drive Isolation Fuses - Fast acting fuses shall be provided to disconnect the VFD

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from the line prior to clearing upstream branch circuit protection to maintain bypass operation capability in the event of a VFD failure. Bypass designs which have no such fuses, or that incorporate fuses common to both the VFD and the bypass, will not be accepted. Third contactor "isolation contactors" are not an acceptable alternative to fuses, as contactors could weld closed and are not an NEC recognized disconnecting device.

5. Bypass Mode: Field-selectable Automatic or Manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic-control system feedback. The bypass system shall be designed for stand-alone operation and shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the system for repair / replacement. Serial communications shall remain functional even with the VFD removed. Bypass systems that do not maintain full functionality with the drive removed are not acceptable.
 6. Class 10, 20, or 30 (programmable) electronic motor overload protection shall be included.
 7. Bypass Controller: Two-contactor-style (bypass and output) bypass allows motor operation via the VFD or the bypass controller; with input isolating switch arranged to isolate the power to the VFD and permit safe troubleshooting and testing, both energized and de-energized, while the motor is operating in bypass mode.
 - a. Bypass Contactor: Load-break, IEC-rated contactor.
 - b. Output Isolating Contactor: Non-load-break, IEC-rated contactor.
 - c. Isolating Switch: Non-load-break switch arranged to isolate the VFD and permit safe troubleshooting and testing of the VFD, both energized and de-energized, while the motor is operating in bypass mode.
 8. Bypass Configuration:
 - a. Less than 75 horsepower: Full-voltage (across-the-line) non-reversing.
 - b. 75 horsepower and above: Reduced voltage soft start.
- U. The VFD power circuit shall be fused and isolated internally with respect to ground. Phase loss protection shall be provided to prevent single phasing.
- V. The VFD shall be capable of continued operation during an intermittent loss of power for 0.1 seconds (6 cycles). Opening of the VFD's input and/or output line switches while operating shall not result in damage to the power circuit components.
- W. The VFD shall have an instantaneous electronic trip circuit breaker to protect the VFD from output line-to-line and line-to-ground short circuits.
- X. Surge Suppression: Factory installed as an integral part of the VFD, complying with UL 1449 SPD, Type 1 or Type 2. The VFD shall include a coordinated AC transient surge protection system consisting of 4 MOVs (phase to phase and phase to ground), a

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capacitor clamp, 1600 PIV Diode Bridge and internal chokes. The MOV's shall have a minimum 125 joule rating per phase across the diode bridge. VFDs that do not include coordinated AC transient surge protection shall include a Surge Protection device Joslyn JSP, SSI or approved equal as an integral component to the VFD package.

- Y. The VFD shall be able to start into a rotating motor (any speed or direction) and accelerate (decelerate) to set speed without tripping or component loss.
- Z. The maximum cable length between the VFD and the motor is 100 feet (30 m). Provide integral Dv/Dt output filters on load side of drive for motor protection where length is greater than 100 feet. Line reactors are not an acceptable substitute for the Dv/Dt output filter.

AA. Enclosures:

- 1. VFD Enclosures: Enclosures shall be UL508, listed as a complete assembly from the factory or shall be evaluated in the field by a Nationally Recognized Testing Laboratory (NRTL) under a field evaluation program. Enclosures shall be suitable for floor or wall mounting as indicated. Enclosure type shall be provided according to environmental conditions at installed location as indicated below:
 - a. Dry and Clean Indoor Locations: UL Type (NEMA) 1.
 - b. Outdoor Locations: UL Type (NEMA) 3R.
 - c. Outdoor Corrosive Locations: UL Type (NEMA) 3R Stainless Steel Construction.
 - d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: UL Type (NEMA) 12.
 - e. Filtered or Non-filtered design as indicated on design drawings.
- 2. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFD as "Plenum Rated."
- 3. See drawings for enclosure type.

2.4 HARMONIC CONDITIONING AND LINE FILTERING

- A. Input Line Conditioning: Harmonic filtering indicated on the drawings shall be provided in compliance with the following:
 - 1. At a minimum, provide an input filter with 5% impedance. 5% impedance may be from dual (positive and negative DC bus) reactors, or 5% swinging AC line reactors. VFDs with only one DC reactor shall add an AC line reactor, no exceptions.
 - 2. Acceptable additional harmonic filtration mitigation devices:

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- a. Integral AC Line Reactors
 - b. Integral passive harmonic filters
 - c. Active front end
 - d. 12 pulse or 18 pulse PWM design
- B. Output Filtering: Provide dV/dT output filters on load side of drive for motor protection where length exceeds motor manufacturer recommendations or 100 feet, whichever is smaller.
- C. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for First Environment restricted level (Category C2) with up to 100 feet of motor cable.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install motor starters, controllers and motor control centers as indicated on the Drawings, in strict accordance with the manufacturer's written instructions, and in compliance with recognized industry practices.
- B. Install fuses or current limiters when required by the equipment specifications.
- C. Tighten connections and terminations in accordance with the manufacturer's published torque tightening values or in accordance with UL Standard 486A and B when manufacturer's values are not indicated.
- D. Prior to energizing equipment, check power and control wiring for correct installation. After energizing equipment, check each motor for proper phase rotation, correct where necessary, and demonstrate operation of starter and accessories.
- E. Program VFDs as required for each individual load. Programming shall include preset speeds, restart attempts and delays, overload settings, frequency avoidance bands, etc.
- F. The installation of external filters with VFDs shall include all necessary conduit and wiring between the filter and the VFD. Where VFD bypass switches are provided, filter shall be connected so that it is isolated from the VFD in the bypass mode.
- G. Set all MCPs in accordance with manufacturer's instructions. Set all overloads in accordance with motor manufacturer instructions.

3.2 SPARE PARTS

- A. Provide ten (10) lamps of each type and rating supplied with the specified equipment.
- B. Provide one (1) of each type of fuse and current limiter for each ten (10) installed, but not less than three (3) of each type and rating.

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C. VFD Keypad: Provide one keypad for each type of VFD provided.

END OF SECTION 262913

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SECTION 263533 - POWER FACTOR CORRECTION

PART 1 - GENERAL

1.1 SUMMARY

- A. Scope: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, configuration and installation for power factor correction equipment (also identified as automatic capacitor banks, PFC equipment) as required for the complete performance of the Work, as shown on the Drawings, and as specified herein.
- B. Related Sections: Related sections include, but shall not be limited to, the following:
 - 1. The Drawings and Division 26 Section, Basic Electrical Materials and Methods, apply to this Section.

1.2 REFERENCES

- A. General, Publications: The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.
 - 1. American National Standards Institute (ANSI)
 - a. ANSI C37.51, "Switchgear Metal Enclosed Low Voltage AC Power Circuit Breaker Switchgear Assemblies Conformance Test Procedures."
 - 2. American Society for Testing and Materials (ASTM)
 - a. ASTM E 329, "Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction."
 - 3. Canadian Standards Association (CSA)
 - a. C.22.2 No. 190, "Capacitors for Power Factor Correction."
 - b. C22.1, "Canadian Electrical Code, Part I" (CEC)
 - c. Z462, "Workplace Electrical Safety"
 - 4. National Electrical Manufacturers Association (NEMA)

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- a. NEMA 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)"
- 5. National Fire Protection Association (NFPA)
 - a. NFPA 70, "National Electrical Code" hereinafter referred to as NEC.
 - b. NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplaces"
- 6. Underwriters Laboratories, Inc. (UL)
 - a. UL 508a, "Industrial Control Panels"
 - b. UL 810, "Standard for Capacitors."

1.3 DEFINITIONS

- A. Unless specifically defined within the Contract Documents, the words or acronyms contained within this specification shall be as defined within, or by the references listed within this specification, the Contract Documents, or, if not listed by either, by common industry practice.

- 1. PFC: Power Factor Correction

1.4 SUBMITTALS

- A. Submit manufacturer's data sheets, wiring schematics and installation dimensional drawings for Owner/Engineer review, comments, and/or approval.
- B. Identify all specified items on submittals to assure compliance and ease of review and/or approval.
- C. Prior to final test and acceptance, submit four (4) complete sets of final data sheets, schematics and dimensional drawings in neat brochure form.
- D. Submittal data required:
 - 1. Dimensioned plan view of all equipment.
 - 2. Size and weight of individual shipping units.
 - 3. Complete diagrams of all control and power connections.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of specified products of types and sizes required, and whose

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products have been in satisfactory use in similar service for a minimum of 20 years.

- B. Installer Qualifications: Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing low voltage automatic capacitor banks similar in type and scope to that required for this Project.
- C. All work performed and all materials used shall be in accordance with the National Electrical Code, and with applicable local regulations and ordinances. Process controllers, assemblies, materials, and equipment shall be listed and labeled by Underwriter's Laboratories or by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Prior to delivery to the Project site, ensure that suitable storage space is available to store materials in a well ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres. Materials shall be protected during delivery and storage and shall not exceed the manufacturer stated storage requirements. As a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. In addition, protect electronics from all forms of electrical and magnetic energy that could reasonably cause damage.
- B. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and equipment tag number or service name as identified within the Contract Documents.
- C. Inspect and report any concealed damage or violation of delivery storage, and handling requirements to the Engineer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D VarSet, by Schneider Electric.

2.2 GENERAL REQUIREMENTS

- A. Capacitor bank shall be able to select a target power factor, adjustable to any value between 0.80 lagging and unity. When the power factor differs from the target setting for more than 1 to 30 seconds, capacitor bank shall bring the corrected circuit power factor to the closest target setting.

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- B. Electrical Components, Devices, and Accessories: Electrical components, devices, and accessories shall be listed and labeled as defined in NEC, Article 100, by an inspecting and testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. The complete equipment shall be manufactured per UL 508, and CSA 22.2 No. 190.
- D. Capacitor equipment shall be suitable for the following conditions:
 - 1. Operating ambient temperature range shall be 23 °F (5 °C) to 104 °F (40 °C) maximum.
 - 2. Highest mean over any period of 24 hours shall be 104 °F (40 °C).
 - 3. Highest mean over one year shall be 95 °F (35 °C).
 - 4. Maximum Altitude: 6562 feet (2000 m).
 - 5. Humidity: 0 percent to 95 percent, non-condensing.

2.3 POWER FACTOR CORRECTION UNITS

- A. Equipment Size / Ratings:
 - 1. Operating voltage shall be 480 volts (line to line), three phase, 60 hertz.
 - 2. Rated capacitor cell voltage shall be minimum of 575 volts for 480 Volt networks.
 - 3. Total kVAR rating of the capacitor bank shall be per the drawings.
 - 4. Capacitor steps shall be per the manufacturer's recommendation.
 - 5. If the incomer has terminal lugs, then the same shall be of copper and all copper buswork shall be braced to withstand fault level at either 25 kA RMS amperes symmetrical plus 10 percent for four cycles per ANSI C37.51.
- B. Enclosure:
 - 1. Enclosure(s) shall be freestanding / wall mounted, and shall be constructed of sheet steel, including, but not limited to a hinged door, ground lug, and removable lifting eyes.
 - 2. Enclosure(s) shall meet NEMA 250 Type 1 for indoor application.
 - 3. Enclosure door(s) shall be full height, key lockable with door mounted controller, to comply with NFPA70E requirements.
- C. Capacitors:

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1. Internal capacitor cells shall be UL and CSA recognized in compliance with UL 810 and CSA22.2, No. 190.
 2. Liquid filled or impregnated capacitors are not acceptable. Individual capacitor elements shall be of a self-healing design utilizing a low loss metalized film dielectric system with a pressure sensitive circuit interrupter. Electrical losses, including, but not limited to, contribution of discharge resistors, shall average less than 0.5 watts per kVAR.
 3. Capacitor shall be able of continuous operation at 135 percent of the rated rms current, including fundamental and harmonic currents, and be suitable for continuous operation at terminal to terminal voltage (rms including harmonics) equals to 110% of the rated voltage.
 4. Capacitor elements shall be delta connected at rated voltage. Wye connected capacitor elements shall not be acceptable.
 5. Capacitor shall incorporate a 3-phase pressure switch disconnector for protection against internal faults, over pressure, etc. The pressure switch disconnector must isolate all the three phases simultaneously in the event of fault.
 6. Discharge resistors shall be provided to meet UL/CSA requirement (reduce voltage on the cells to 50 volts or less within one minute after the capacitor has been switched off).
- D. Internal Overcurrent Protective Device: Thermal magnetic molded case current limiting circuit breaker shall be provided on the line side of each contactor. Circuit breaker shall be UL/CSA listed, shall have inverse time current element for low level overloads, and shall have adequate short circuit current interrupting rating.
- E. Contactors:
1. For applications with gradual load variation, electromagnetic contactors shall be used. The electromagnetic contactors shall be three poles; rated for the repetitive high inrush switching duty in the capacitor application. Contactors shall be designed for capacitor switching duty, UL / CSA listed and rated 600 volts AC with 120 volts AC operating coils.
 2. For applications with dynamic load variation or electronic loads that are sensitive to transient over voltages, transient free switching shall be used. Transient free switching with (solid state capacitor switching module) shall enable a 1 second response time. The thyristors in the switching module shall be rated to 200 amperes RMS nominal current per phase up to 600V, and shall be rated for 2400 PIV. Up to 3 stages can grouped in a single switching module for effective thermal management. The switching module shall be protected by thermal protection device to prevent overheating. The air flow through the heat sink shall be external to the capacitor bank. Losses from the heat sink, shall not add to the temperature rise internal to the capacitor bank.

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F. De-Tuning Reactors:

1. Tuning reactors for each capacitive stage shall be selected such that filter tuning of each stage shall be equal to 4.2×60 hertz equivalent to a 252 Hz tuning.
2. Reactor shall be constructed of EI laminated low hysteresis core with a controlled air gap and three aluminum windings.
3. Reactor insulation shall be rated for 180 °C, class H.
4. Center leg of tuning reactor shall have an embedded thermistor wired to a thermistor relay for the stage to deenergize the associated contactor in the event of reactor overheating.

G. Control Power Requirements:

1. 120 volt AC control circuit transformer shall be provided within the enclosure.
2. Major components, including, but not limited to, both primary and secondary winding of the transformer, shall be fused.

H. Power Factor Controller:

1. The PF controller shall be a programmable unit with a single current input and single line to line voltage input. The controller shall be suitable for operation with energy import and energy export (4 quadrant operations). The controller shall measure power factor in the distribution system, and per the programmed control logic, shall connect or disconnect the required amount of capacitor stages needed to maintain the preset power factor.
2. The controller shall utilize a switching logic that shall optimize the use of capacitor elements and contactors in the bank. Three switching logics shall be available; Automatic (Best Fit), LIFO & Progressive.
3. A backlit LCD display shall be provided to view the system condition and gain access to all the menus. Indication of actual Power Factor, Alarms, stage energization and inductive/capacitive condition shall be provided.
4. Backlit LCD display shall light up when the controller is being accessed.
5. The controller shall be equipped with a quick set up menu to allow for simple and quick startup of the Automatic Capacitor bank.
6. The controller shall also be equipped with an expert setup menu allowing password controlled access to advanced parameters like: measurement, maintenance, controls, capacitor data, alarms and Modbus communication.

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7. When overriding the automatic mode for maintenance, a ten minutes maximum override time shall be provided with an automatic return to automatic mode of operation.
 8. A common alarm dry contact shall be provided to signal an alarm status.
 9. The controller shall automatically select the system frequency (50 hertz or 60 hertz).
 10. An automatic step detection and an automatic voltage and current input wiring connection must be provided to reduce risks of bad connection. CT ratio, position and polarity shall be adjustable by the controller.
 11. The controller shall monitor all connected steps and provide the real-time power in kW, kVAR and kVA. The controller shall also monitor remaining step kVAR capacity as a percentage of the original reactive power and the PFC system hours of operation since commissioning.
 12. The controller shall permit programming of the switching stage response time, number of stages (12 maximum), and various adjustment parameters depending on system design.
 13. The controller shall be equipped with a Modbus RTU (RS 485, 2 wires) communication port. Furthermore, communication via Ethernet TCP/IP shall be possible when an Ethernet gateway (Link 150) is added to the automatic capacitor bank.
 14. A digital input shall be provided to activate the Cosphi #2 for application with back-up generator.
 15. The controller shall allow the following settings and readings.
 - a. Automatic initialization and stage rating detection
 - b. Any step sequence detection (User definable step sequence)
 - c. Measurement of capacitance per stage
 - d. Cap bank over load current ratio
 - e. THD Voltage
 - f. 4 Quadrant operation
 - g. Active, reactive and apparent power
 - h. Record of the Max temp internal of the capacitor bank since reset
 - i. RS485 interface.
- I. The controller shall initiate alarms and warnings in the following events.

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1. Temperature limit is exceeded
2. Insufficient capacitor output
3. Overload current ratio limit is exceeded
4. Under voltage, Over voltage
5. THDU limit is exceeded

2.4 MARKINGS AND LABELING

- A. All identification and warning labels and nameplates exterior to the AHF shall be resistant to weather, UV, and their intended installation environment.
- B. Each AHF shall be provided with an engraved nameplate identifying the project specific equipment tag and service description.
- C. Warning labels and nameplates shall be present at access locations to advise personnel of possible hazards. The AHF shall be marked in accordance with UL, NFPA 70 NEC, NFPA 70E, and other applicable standards.

PART 3 - EXECUTION

3.1 GENERAL

- A. Examine equipment exterior and interior prior to installation. Report any damage and do not install any equipment that is structurally, moisture, or mildew damaged.
- B. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
- C. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.
- D. Install equipment in accordance with reviewed product data, final shop drawings, manufacturer's written instructions and recommendations, and as indicated on the Drawings.
- E. Functional testing, commissioning, and first parameter adjusting shall be carried out by a factory trained manufacturer's representative field service engineer. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment. Report to the Engineer any discrepancies or issues with the installation.

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- F. Provide final protection and maintain conditions in a manner acceptable to the manufacturer that shall help ensure that the equipment is without damage at time of Substantial Completion.

3.2 FUNCTIONAL DEMONSTRATION TESTING

- A. The contractor shall certify in writing prior to scheduling functional demonstration testing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer's recommendations and is ready for operation.
- B. The contractor shall demonstrate the functional and operational features of the capacitor bank along with the PF Controller.

END OF SECTION 263533

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SECTION 263600 - AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, Basic Electrical Materials and Methods, apply to this Section.

1.2 SUMMARY

- A. This specification describes the requirements associated with the automatic transfer switches and associated control devices as indicated on the drawings and as specified herein. The automatic transfer switches shall be manufactured, installed and tested in strict accordance with these specifications.

1.3 SUBMITTALS

- A. Submit the following information for Owner/Engineer review, comments and/or approval:
 1. Product data.
 2. Complete installation drawings, including plan view and elevations with connection of required utilities clearly indicated.
 3. Electrical schematics, wiring diagrams, interconnection diagrams and bussing details.
 4. Statement of compliance and deviation as specified herein.
- B. The manufacturer shall submit a copy of these specifications with each sub-paragraph noted with the comment "compliance", "deviation", or "alternate".
 1. By noting the term "compliance", it shall be understood that the manufacturer is in full compliance with the item specified and will provide exactly the same with no deviations.
 2. By noting the term "deviation", it shall be understood that the manufacturer prefers to provide a different component in lieu of that specified. Manufacturer shall indicate all deviations.
 3. By noting the term "alternate", it shall be understood that the manufacturer proposes to provide the same operating function but prefers to do it in a different manner. Any alternate shall be fully described as to what the manufacturer proposes to provide.
- C. Identify all specified items on submittals to assure compliance and ease of review and/or

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approval.

1.4 QUALITY ASSURANCE

- A. The automatic transfer switches shall conform to these specifications and applicable codes and standards published by the following authorities and associations:
 - 1. National Fire Protection Association (NFPA)
 - 2. Underwriter Laboratories (UL), UL 1008
 - 3. NFPA 70, National Electrical Code (NEC)
 - 4. American National Standards Institute (ANSI)
 - 5. National Electrical Manufacturers Association (NEMA)
 - 6. American Society of Testing and Materials (ASTM)
 - 7. Institute of Electrical and Electronics Engineers (IEEE)

PART 2 - PRODUCTS

2.1 AUTOMATIC TRANSFER SWITCHES

- A. The automatic transfer switch shall be factory assembled with the current ratings, voltages and accessories as indicated on the drawings or specified herein.
- B. The switch and all of its associated controls and terminations shall be completely front accessible.
- C. The switch shall be mechanically held in both the normal and the emergency positions, and rated for continuous duty in an unventilated enclosure. The switch shall be open transition, break-before-make, double throw with the main contacts rigidly and mechanically interlocked to insure three possible positions: Normal, Emergency or Neutral.
- D. The automatic transfer switch shall be of the motor or solenoid type. Circuit breaker type switches are not acceptable and will not be considered.
- E. The ATS shall be UL listed, STD UL-1008, with withstand and close-in values which match the overcurrent protective devices for the normal and emergency feeders.
- F. The ATS shall be provided in a NEMA type 1 enclosure suitable for the location where the switch will be installed.
- G. All bus shall be copper.
- H. The ATS shall be four-pole. The four-pole switches shall have ratings identical to the

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other poles and shall be mounted on the same shaft. Reduced neutral ratings, overlapping neutral contacts and switches which are not true four-pole switches shall not be acceptable.

- I. The ATS shall have a withstand rating equal to the AIC ratings of the circuit breakers from which it is served.

2.2 ACCESSORIES

- A. The ATS shall be provided with the following accessories:
 - 1. Adj. 0.5-3 second time delay on engine start.
 - 2. Adj. 1-300 second time delay on transfer to emergency.
 - 3. Adj. 0-30 minute time delay on transfer to normal.
 - 4. Fixed 5 minute time delay for engine cool-down.
 - 5. Load test switch, maintained type.
 - 6. One (1) contact to open and one (1) contact to close on failure of normal to be used for engine starting.
 - 7. Pilot lights to indicate switch position.
 - 8. Two (2) auxiliary contacts closed in normal.
 - 9. Two (2) auxiliary contacts closed in emergency.
 - 10. Adjustable close differential voltage sensing on all phases of normal, pick-up set at 90%, drop-out set at 85% of nominal.
 - 11. Voltage and frequency sensing of emergency source, voltage pick-up set at 90%, frequency pick-up set at 95% of nominal.
 - 12. An automatic seven (7) day exerciser clock, enabling the engine to be automatically started and run without load for thirty (30) minutes each week at a preprogrammed time period. The transfer switch shall remain in the "normal" position unless a commercial power failure occurs during the exercise period.
 - 13. An additional set of main-shaft auxiliary contacts (1 N.O. and 1 N.C.) and two (2) time delay contacts for connection to the elevator controllers. The time delay contacts shall open twenty (20) seconds (adjustable 1-300 seconds) before transfer in either direction and reclose after transfer is complete.
- B. The ATS shall have an open transition time between the opening of the closed contacts and the closing of the open contacts adjustable from 1-300 seconds.
- C. The ATS shall be equipped with a safe manual operator. The manual operator shall provide the same contact-to-contact transfer speed as the electrical operator. The

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manual operator shall be operable with the ATS door in the closed position.

- D. All relays, timers, control wiring shall be front accessible. All adjustable time delays shall have calibrated marks for field adjustments. Time delay relays/circuits which cannot be accurately set in the field without the use of test equipment are not acceptable.

2.3 OPERATION

- A. Upon loss of normal power and after an adjustable time delay, the switch shall signal the standby generator to start.
- B. The transfer switch shall transfer to emergency when the output of the standby generator reaches 90% of rated voltage and 95% of rated frequency. If the emergency source is not available, or if the generator voltage is less than 90% nominal, transfer to emergency shall be inhibited.
- C. After the normal source has been restored to 90% of rated voltage, the transfer switch shall retransfer to the normal source after an adjustable time period of 0 to 30 minutes.
- D. The standby generator shall continue to run unloaded for five (5) minutes and then shutdown. All controls shall automatically reset in preparation for the next power failure.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install the automatic transfer switches in the space shown.
- B. Connect auxiliary and control contacts in ATS to the engine-generator control panel in accordance with the engine-generator manufacturer's instructions. For emergency generator applications, control conductors installed between the transfer switch and the generator shall be as follows:
 1. Control wire installation shall comply with NEC Article 700.10 (D)(3).
 2. The control conductors shall be kept entirely independent of all other wiring and shall meet the conditions of NEC Article 700.10 (D)(1).
 3. The integrity of the generator remote start circuit shall be monitored for broken, disconnected, or shorted wires. Loss of integrity shall start the generator(s).
- C. Connect auxiliary and control contacts in ATS to the fire alarm annunciators and controls in accordance with the fire alarm instructions.

3.2 TESTING AND CERTIFICATION

- A. Test and demonstrate to the Owner's representative (with factory representative present) that the transfer switch meets the requirements of this specification.

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- B. Demonstration shall include, but not be limited to, the operation of all time delays, starting contacts, and transfer functions.
- C. All testing shall be scheduled at the convenience of the Owner, and shall be arranged at least two (2) weeks in advance.
- D. Services shall include a minimum of two (2) visits by representatives of the ATS manufacturer as follows:
 1. Following installation, the manufacturer of the ATS shall inspect and verify the correct installation of the ATS. All individual components shall be checked. Power conductors and control circuits shall also be checked.
 2. The manufacturer of the ATS shall provide the services of a qualified technician for initial start-up. Checks and services shall be conducted to prepare equipment for energization.
 3. Field service must be unlimited and must continue until satisfactory system operation and customer approval has been achieved.
 4. Prior to system turnover, an instruction period for operation shall be provided.
- E. Final data sheets, schematics, dimensional drawings, and operating and maintenance instructions shall be provided. This information shall be provided in the operating and maintenance manuals specified in Division-26 Section, Basic Electrical Materials and Methods.

END OF SECTION 263600

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SECTION 264313 - INTEGRATED SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and Division-26 Section, Basic Electrical Materials and Methods, apply to this section.

1.2 SCOPE

- A. The Contractor shall furnish and install the Surge Protective Device (SPD) equipment having the electrical characteristics, ratings and modifications as specified herein and/or as shown on the contract drawings. To maximize performance and reliability, and to obtain the lowest possible let-through voltages, the AC surge protection is to be integrated into electrical distribution equipment such as switchboards.

1.3 REFERENCES

- A. SPD units and all components shall be designed, manufactured, and tested in accordance with the latest applicable standards
1. ANSI/UL 1449 4th Edition or later
 2. ANSI/UL 1283 5th Edition or later (Type 2 applications)
 3. IEEE C62.41.1
 4. IEEE C62.41.2
 5. IEEE C62.43-2005
 6. IEEE C62.45-2002
 7. IEEE C62.48-2005
 8. IEEE C62.62-2010
 9. UL 96A
 10. NFPA 780

1.4 SUBMITTALS

- A. Provide verification that the SPD complies with the required ANSI/UL 1449 4th Edition or later listing by Underwriters Laboratories (UL). Compliance may be in the form of a file number that can be verified on UL's website www.ul.org, the website should contain the following information at a minimum: model number, SPD Type, system voltage, phases, modes of protection, Voltage Protection Rating (VPR), and Nominal Discharge Cur

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rent In.

1. Descriptive bulletins.
2. Product sheets.
3. Final record drawings.

1.5 QUALIFICATIONS

- A. The manufacturer of the electrical distribution equipment shall be the manufacturer of the SPD within the listed electrical distribution equipment.
- B. For the equipment specified herein, the manufacturer shall be ISO 14001 and ISO 9001 or 9002 certified.
- C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of twenty-five (25) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- D. The SPD shall be compliant with the Restriction of Hazardous Substances (RoHS) Directive 2011/65/EU and have a visible label showing compliance.
- E. The SPD shall be UL 1449 current edition listed, 20 kA In Type 1 or Type 2 for use in UL 96A systems.
- F. The manufacturer must have a 24-hour response capability with field engineering personnel. The field service organization must have fully accredited Power System Engineers located across the USA who are capable of performing complete grounding, Power Quality analysis, and coordination studies. Factory trained SPD sales personnel do not qualify as Power System Engineers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Schneider Electric, Eaton, Cutler-Hammer or approved equivalent.

2.2 VOLTAGE SURGE SUPPRESSION – GENERAL

- A. Electrical Requirements:

1. Unit Operating Voltage: Refer to drawings for operating voltage and unit configuration.
2. Maximum Continuous Operating Voltage (MCOV): The MCOV shall not be less than 115% of the nominal system operating voltage.
3. The suppression system shall incorporate thermally protected metal-oxide varistors (MOVs) as the core surge suppression

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component for the service entrance and all other distribution levels. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may crowbar the system voltage leading to system upset or create any environmental hazards. End of life mode to be open circuit. Unit with end of life short-circuit mode is not acceptable.

4. Unit shall operate without the need for an external overcurrent protection device (OCPD), and be listed by UL as such. Unit must not require external OCPD or replaceable internal OCPD for the UL Listing.
5. Protection Modes – The SPD must protect all modes of the electrical system being utilized. The required protection modes are indicated by bullets in the following table:

Configuration	Protection Modes			
	L-N	L-G	L-L	N-G
Wye	•	•	•	•
Delta	N/A	•	•	N/A
Single Phase	•	•	•	•
High Leg Delta	•	•	•	•

6. Nominal Discharge Current (In): All SPDs applied to the distribution system shall have a 20kA In rating regardless of their SPD Type (includes Types 1 and 2) or operating voltage. SPDs having an In less than 20kA shall be rejected.
7. ANSI/UL 1449 4th Edition Voltage Protection Rating (VPR): The maximum ANSI/UL 1449 4th Edition VPR for the device shall not exceed the following:

Modes	208Y/120	480Y/277	600Y/347
L-N; L-G; N-G	700	1200	1500
L-L	1200	2000	3000

B. SPD Design:

1. Maintenance Free Design: The SPD shall be maintenance free and

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shall not require any user intervention throughout its life. SPDs containing items such as replaceable single-mode modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.

2. Balanced Suppression Platform: The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating replaceable SPD modules shall not be accepted.
3. Electrical Noise Filter: Each Type 2 unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz using the MIL-STD-220A insertion loss test method. Products unable able to meet this specification shall not be accepted.
 - a. Type 2 units with filtering shall conform to UL 1283 5th Edition.
 - b. Type 1 units shall not contain filtering or have a UL 1283 5th Edition Listing.
4. Internal Connections: No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be soldered, hardwired with connections utilizing low impedance conductors.
5. Monitoring Diagnostics: Each SPD shall provide the following integral monitoring options:
 - a. Protection Status Indicators: Each unit shall have a green / red solid-state indicator light that reports the status of the protection on each phase.
 - 1) For wye configured units, the indicator lights must report the status of all protection elements and circuitry in the L-N and L-G modes. Wye configured units shall also contain an additional green / red solid-state indicator light that reports the status of the protection elements and circuitry in the N-G mode. SPDs that indicate only the status of the L-N and L-G modes shall not be accepted.
 - 2) For delta configured units, the indicator lights must report the status of all protection elements and circuitry in the L-G and L-L modes

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- 3) The absence of a green light and the presence of a red light shall indicate that damage has occurred on the respective phase or mode. All protection status indicators must indicate the actual status of the protection on each phase or mode. If power is removed from any one phase, the indicator lights must continue to indicate the status of the protection on all other phases and protection modes. Diagnostics packages that simply indicate whether power is present on a particular phase shall not be accepted.
 - b. Remote Status Monitor (optional) – The SPD must include Form C dry contacts (one NO and one NC) for remote annunciation of its status. Both the NO and NC contacts shall change state under any fault condition.
 - c. Audible Alarm and Silence Button (optional) – The SPD shall contain an audible alarm that will be activated under any fault condition. There shall also be an audible alarm silence button used to silence the audible alarm after it has been activated.
 - d. Surge Counter (optional) – The SPD shall be equipped with an LCD display that indicates to the user how many surges have occurred at the location. The surge counter shall trigger each time a surge event with a peak current magnitude of a minimum of $50 \pm 20A$ occurs. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed. The reset button shall contain a mechanism to prevent accidental resetting of the counter via a single, short-duration button press. In order to prevent accidental resetting, the surge counter reset button shall be depressed for a minimum of 2 seconds in order to clear the surge count total.
 - 1) The ongoing surge count shall be stored in non-volatile memory. If power to the SPD is completely interrupted, the ongoing count indicated on the surge counter's display prior to the interruption shall be stored in non-volatile memory and displayed after power is restored. The surge counter's memory shall not require a backup battery in order to achieve this functionality.
6. Thermal MOV Protection:
- a. The unit shall contain thermally protected MOVs. These self-protected MOVs shall have a thermal protection element integrated with the MOV and a mechanical disconnect with arc quenching capabilities in order to

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achieve overcurrent protection of the MOV. The thermal protection assembly shall disconnect the MOV(s) from the system in a fail-safe manner should a condition occur that would cause them to enter a thermal runaway condition.

7. Fully Integrated Component Design: All of the SPD's components and diagnostics shall be contained within one discrete assembly. The use of plug in single-mode modules that must be ganged together in order to achieve higher surge current ratings or other functionality shall not be accepted.
8. Safety Requirements:
 - a. The SPD shall minimize potential arc flash hazards by containing no single-mode plug in user serviceable / replaceable parts and shall not require periodic maintenance. SPDs containing items such as replaceable single-mode plug in modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
 - b. SPDs designed to interface with the electrical assembly via conductors shall require no user contact with the inside of the unit. Such units shall have any required conductors be factory installed.

2.3 SYSTEM APPLICATION

- A. The SPD applications covered under this section include distribution and branch panel locations, busway, motor control centers (MCC), switchgear, and switchboard assemblies. All SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C, B, and A environments.
- B. Surge Current Capacity: The minimum surge current capacity the device is capable of withstanding shall be as shown in the following table:

Minimum surge current capacity based on ANSI / IEEE C62.41 location category			
Category	Application	Per Phase	Per Mode
C	Service Entrance Locations (Switchboards, Switchgear, MCC, Main Entrance)	250 kA	125 kA

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B	High Exposure Roof Top Locations (Distribution Panelboards)	160 kA	80 kA
A	Branch Locations (Panelboards, MCCs, Busway)	120 kA	60 kA

2.4 SWITCHBOARD REQUIREMENTS

- A. The SPD application covered under this section is for switchgear, switchboard, MCC, and busway locations. Service entrance located SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C environments.
- B. The SPD shall be of the same manufacturer as the switchgear, switchboard, MCC, or busway
- C. The SPD shall be factory installed integral to the switchgear, switchboard, MCC, and/or bus plug at the assembly plant by the original equipment manufacturer
- D. Locate the SPD on the load side of the main disconnect device, as close as possible to the phase conductors and the ground/neutral bar.
- E. The SPD shall be connected through a disconnect (30A circuit breaker). The disconnect shall be located in immediate proximity to the SPD. Connection shall be made via bus, conductors, or other connections originating in the SPD and shall be kept as short as possible.
- F. The SPD shall be integral to switchgear, switchboard, MCC, and/or bus plug as a factory standardized design.
- G. All monitoring and diagnostic features shall be visible from the front of the equipment.

2.5 SERVICE ENTRANCE REQUIREMENTS

- A. Service entrance located SPDs shall be tested and designed for applications within ANSI/IEEE C62.41 Category C environments.

PART 3 - EXECUTION

3.1 EXAMINATION

3.2 FACTORY TESTING

- A. Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of NEMA, IEEE, and UL standards.

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3.3 INSTALLATION

- A. The installation of the SPD shall be factory installed integral to the distribution equipment. The Contractor shall install all distribution equipment per the manufacturer's recommendations, applicable electrical codes and the contract drawings.

3.4 WARRANTY

- A. The manufacturer shall provide a ten (10) year warranty (15 year warranty with registration) that covers replacement of the complete unit, including lightning, from the date of shipment against any SPD part failure when installed in compliance with manufacturer's written instructions and any applicable national or local electrical code.

END OF SECTION 264313

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SECTION 265000 - LIGHTING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

- A. This section provides general requirements for a complete and fully operational lighting system including:
 - 1. Interior lighting fixtures
 - 2. Exterior lighting fixtures
 - 3. Lamps
 - 4. Ballasts
 - 5. Accessories
 - 6. Light fixture support

1.2 RELATED SECTIONS

- A. Basic Materials and Methods
- B. Wiring Devices
- C. Grounding
- D. Supporting Devices
- E. Lighting Control Systems

1.3 REFERENCES

- A. The Work under this section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and Sections under Division-01 General Requirements.
- B. Conform to Reference Standards by date of issue current on date of Contract Documents, except where a specific date is established by code.
 - 1. ANSI/NFPA 70 National Electrical Code
 - 2. NFPA 101 Life Safety Code
 - 3. UL 57 Electrical Luminaires

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4.	UL 542	Lampholders, Starter Holders for Fluorescent Lamps
5.	UL 924	Emergency Lighting and Power Equipment
6.	UL 935	Fluorescent Lamp Ballasts
7.	UL 1472	Solid-State Dimming Controls
8.	UL 1570	Fluorescent Luminaires
9.	UBC	Standard Section 47.1813 Luminaires
10.	IES LM-79-08	Electrical and Photometric Measurements of Solid State Lighting
11.	IES LM-80	Method for Measuring Lumen Maintenance for SSL Light Sources

1.4 SYSTEM DESCRIPTION

- A. The Lighting Fixture Schedule and catalog numbers indicated are a design series reference and do not necessarily represent the exact catalog number, size, voltage, wattage, type of lamp, ballast, finish trim, ceiling type, mounting hardware, or special requirements as specified or as required by the particular installations. Provide complete fixture to correspond with the features, accessories, number of lamps, wattage and/or size specified in the text description of each fixture type. Additional features, accessories and options specified shall also be included to provide a complete and operable system.
- B. Provide all frames, supplementary support structures, hangers, spacers, stems, aligner canopies, auxiliary junction boxes and other hardware as required for a complete and proper installation. Recessed fixtures shall have frames that are compatible with the ceiling systems.
- C. Light fixture voltage shall match the voltage of the circuit serving the light fixture.

1.5 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.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- C. Comply with applicable requirements of local codes and NEC Articles 220 and 410 as applicable to construction and installation of lighting fixtures.
- D. Comply with applicable NEMA, IES and UL standards. Lighting fixtures and components

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- shall be UL listed and labeled.
- E. Fluorescent ballasts shall have a CBM label.
 - F. Comply with NFPA 70.
 - G. Luminaires, ballasts, lamps and other components and controls shall equal or exceed the requirements of all applicable state and/or municipal energy codes.
 - H. Designated manufacturers are listed to define the requirements for quality and function of the specified product. Equivalent or better products of other, unnamed manufacturers may be proposed for consideration by adhering to procedures set forth in this section and in other Division-01 specification sections.
 - I. Mockups: Refer to the Lighting Fixture Schedule for fixture type(s) requiring mockups. Provide lighting fixtures for room or module mockups.
 - 1. Obtain Engineer's and Architect's approval of fixtures for mockups prior to starting installation.
 - 2. Install fixtures for mockups with power and control connections.
 - 3. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 4. Remove mockups when directed. Fixtures may be reinstalled in the Work with approval of Owner.
 - 5. Mockups evaluated on the project site may become part of the complete Work with the approval of the Owner, Engineer, and Architect if the mockup is undisturbed at the time of substantial completion.

1.6 SUBMITTALS

- A. Comply with requirements of specification section describing Submittal Procedures. Also, refer to the electrical specification section, Basic Materials and Methods, for re-submittal requirements.
- B. The authorized manufacturer's representative for the project area shall prepare submittals for each lighting fixture type. In addition to the fixture submittals, a list shall be provided identifying the manufacturer representative for each fixture type. Provide manufacturers' names, addresses, and telephone numbers.
- C. Light fixture submittals shall include the fixture, lamp, ballast and maximum input wattage for each and every fixture in one submittal package. This information shall be clearly indicated in the submittal. The lighting fixture submittal package will not be reviewed until this information is submitted as required. Input wattage shall not exceed the maximum allowable total input watt value shown in the lighting fixture schedule.
- D. Light fixtures shall be coordinated with project specific lighting control system devices.

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Provide a letter/ statement in the lighting fixture submittal that conforms that all lighting fixtures have been coordinated with the specific lighting control system devices that will be used on this project.

- E. Light fixtures shall be coordinated with project specific lighting control system devices. Provide a letter/ statement in the lighting fixture submittal that conforms that all lighting fixtures have been coordinated with the specific lighting control system devices that will be used on this project.
- F. Product Data shall indicate that light fixture, lamps, ballasts, input watts and controls fully comply with contract documents. Data shall be submitted for each type of light fixture indicated, arranged in order of fixture designation. For standard catalog fixtures provide original product catalog sheets indicating data on features, accessories, finishes, and the following:
 - 1. Materials and dimensions of luminaires.
 - 2. Photometric data, in IESNA format, based on certified results of laboratory tests of each light fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the light fixture as applied in the Project.
 - a. Photometric data shall be certified by a qualified independent testing agency.
 - b. Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.
 - 3. Emergency lighting unit battery and charger.
 - 4. Low voltage transformers.
 - 5. Fluorescent and high intensity discharge ballasts.
 - 6. LED drivers and power supplies.
 - 7. Types of lamps, including manufacturer, wattage, and Color Rendering Index (CRI) and color temperature in degrees Kelvin (K).
 - 8. Air and Thermal Performance Data: For air-handling light fixtures, furnish data required in "Submittals" Article in Division-23 Section "Air Outlets and Inlets."
 - 9. Sound Performance Data: For air-handling light fixtures, indicate sound power level and sound transmission class in test report certified according to standards specified in Division-23 Section "Air Outlets and Inlets."
- G. Shop Drawings shall:
 - 1. Show details of nonstandard or custom fixtures.
 - 2. Indicate dimensions, weights, method of field assembly, components, features, and accessories.

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3. For custom fixtures, modified fixtures, or linear fluorescent fixtures mounted in continuous rows, submit scaled drawings prepared by the manufacturer showing all details of construction, lengths of runs, pendant and power feed locations, accessories, finishes, and lists of materials.
 4. Contractor to provide the manufacturer with accurate field dimensions where required.
 5. Include wiring diagrams, power and control wiring.
- H. Wiring Diagrams shall detail wiring for fixtures and differentiate between manufacturer-installed and field-installed wiring.
- I. Product Certificates shall be signed by manufacturers of lighting fixtures certifying that products comply with requirements.
- J. Dimming Ballast Compatibility Certificates shall be signed by the manufacturer of ballast certifying that ballasts are compatible with dimming systems, equipment and controls with which they are used. Product certificates signed by the product manufacturer shall be provided for each type of ballast for bi-level and dimmer controlled fixtures.
- K. Provide confirmation of approval by both the manufacturer of dimming LED fixtures and manufacturer of dimming control components that their products will meet specified performance criteria and warranty when used together.
- L. Maintenance Data shall be provided for lighting fixtures and equipment to include in emergency, operation, and maintenance manuals specified in specifications section describing Operations and Maintenance Data.
- M. Field quality control test reports.
- N. Special Warranties specified in this Section.
- O. Review of luminaire submittals which indicate voltage, mounting condition, or quantities shall not be considered to be approval of said voltage, mounting condition, or quantities. Contractor shall field verify voltage and actual mounting condition and method.
- P. Product samples, complete with housing, trim, specified lamp, and 8' cord with plug wired for 120V operation shall be submitted if requested.

1.7 SUBSTITUTIONS

- A. Substitutions shall include all information required under in paragraph 1.06 - SUBMITTALS. Provide the name of at least one installation where each proposed substitute has been installed for at least six months. Provide the name and telephone number of the Architect, Owners' Representative, and Lighting Designer or Engineer of record.
- B. Equipment delivery lead time shall not be held as a valid reason for submitting a luminaire substitution. It shall be the sole responsibility of the Contractor to determine

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necessary equipment lead times, deliver submittals for review in a timely fashion, and place orders accordingly to ensure timely delivery.

- C. Submittal for Product Substitutions: All products submitted which are other than the make and model called out in the Construction Documents are considered "Substitutions". The Contractor must submit the following for all substitutions:
 - 1. Provide cut sheet/product data for substitute item, including list price.
 - 2. Provide cut sheet/product data for specified item, including list price.
 - 3. Provide point-by-point photometric calculations using the substitute light fixture(s) for the entire project area or portions thereof as directed by the Engineer. The Contractor is responsible for contacting the Engineer to obtain the required calculation parameters. Point spacing, total light loss, work plane height, and other parameters shall be provided upon request in order to match the Engineer's photometric model. Submittal review will be withheld until photometric calculations for substitutions are received.
 - 4. When requested by the Engineer, provide a light fixture sample of the specified fixture and the substitute fixture for comparison. Samples shall be complete with lamps and cord/plug for 120V operation.
 - 5. It is the Contractor's responsibility to prove that substitutes are "equal".
 - 6. Confirm that controls are compatible with substitute light fixtures.
 - 7. Confirm that energy code requirements are met when using the substitute fixtures.
 - 8. Redesign is the responsibility of the contractor.
- D. A maximum of one substitution requests shall be reviewed for any single fixture type. If a substitution has not been approved following this process, the Contractor shall provide the specified fixture.

1.8 COORDINATION

- A. Coordinate layout and installation of light fixtures with ceiling system and other construction that penetrates ceilings or is supported by them including mechanical system, fire suppression, AV, and partition assemblies.
- B. Provide all frames, supplementary support structures, hangers, spacers, stems, aligner canopies, auxiliary junction boxes and other hardware as required for a complete and proper installation. Recessed fixtures shall have frames that are compatible with the ceiling systems.
- C. Coordination Meetings: Meet at least twice with the ceiling installer. Hold first meeting before submittal of shop drawings to coordinate each light fixture mounting condition with ceiling type. During second meeting, coordinate fixture layout in each area. Meet at least twice with the mechanical systems installer prior to fabrication and installation of

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ductwork. Coordinate depth and location of all light fixtures and ductwork in all areas.

1.9 WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Special Warranties for Fluorescent Ballasts: Written warranty, executed by manufacturer agreeing to replace fluorescent ballasts that fail in materials or workmanship within specified warranty period.
 - 1. Special Warranty Period for Electronic Ballasts: Five years from date of manufacture, but not less than four years from date of Substantial Completion.
 - 2. Special Warranty Period for Electromagnetic Ballasts: Manufacturers' standard warranty, but not less than three years from date of manufacture.
- C. Special Warranty for Fluorescent Lamps: Manufacturer's standard form, made out to Owner and signed by lamp manufacturer agreeing to replace lamps that fail in materials or workmanship, freight on board the nearest shipping point to Project site, within specified warranty period indicated below.
 - 1. Warranty Period: Two years from date of Substantial Completion.
- D. Special Warranty for LED Lighting Fixtures: A warranty must be provided by the manufacturer made out to Owner for luminaires, covering repair or replacement of defective electrical parts (including light engine, driver and power supplies) within specified warranty period indicated below.
 - 1. Warranty Period: Five years from date of Substantial Completion.

1.10 EXTRA MATERIALS

- A. Contractor shall include 5 exit light fixtures, in addition to the fixtures shown on the drawings, inclusive of associated labor and material to install after final walk-thru by Fire Marshal. Devices shall be installed in locations as directed by Fire Marshal, and shall include all cutting, patching and finishing of walls. All unused fixtures shall be turned over to the owner for use as spares.
- B. Contractor shall include 5 emergency light fixtures inclusive of associated labor and material to install after final walk-thru by Fire Marshal. Devices shall be installed in locations as directed by Fire Marshal and shall include all cutting, patching and finishing of walls. All unused fixtures shall be turned over to the Owner for use as spares.
- C. Furnish extra materials described below, or as described in the Lighting Fixture Schedule, that match product installed and that are packaged with protective covering for storage and identified with labels describing contents.

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1. Glass and Plastic Lenses, Covers, Louvers, and Other Optical Parts: 10% or one dozen (whichever is less) of each type and rating installed. Furnish at least one of each type.
2. LED light engines, drivers, and power supplies: 10% extra individual modular LED strips or replaceable source modules, drivers and power supplies. If product does not have replaceable components, furnish at least 10% extra entire fixture assembly. Furnish at least one of each type.
3. Furnish spare lamps amounting to 15 percent of installed capacity, but not less than four (4) lamps, of each type and rating used on the project. Deliver spare lamps to the Owner's place of storage

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Catalog series numbers shown on the Lighting Fixture Schedule on the drawings represent the type and style of fixture. The fixture size shall correspond with the actual length of the fixture as indicated on the drawings.
- B. Numbers are a design series reference and do not necessarily represent the exact catalog number, size, voltage, wattage, type of lamp, type of ballast, finish trim, ceiling type, mounting hardware or special requirements as specified as required by the particular installations. Acceptable manufacturers and series numbers are listed. The manufacturer listed shall provide complete fixtures equaling or exceeding the written specifications. Verify these requirements and order fixtures as required for a complete and fully operational installation per the contract documents and per code.

2.2 GENERAL MATERIAL REQUIREMENTS

- A. Fixtures shall be free of light leaks while providing sufficient ventilation of lamps to provide the required photometric performance. Ballasts and transformers shall be adequately vented.
- B. Lampholders shall hold lamps securely against normal vibration and maintenance handling.
- C. Light fixtures containing lamps which require protective shielding shall be furnished with a tempered glass lens or approved unbreakable lens UL listed for the application.
- D. Metal parts shall be free from burrs, sharp corners, and edges. Metal work shall be free from tool marks and dents and shall have accurate angles bent as sharply as compatible with the gauges of the required metal. Intersections and joints shall be formed true and of adequate strength and structural rigidity to prevent any distortion after assembly. All miters shall be in accurate alignment with abutting intersection members.
- E. Sheet metal components shall be steel, unless otherwise indicated. Components shall

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be formed and supported to prevent warping and sagging. Luminaires to be painted after fabrication. Finish ferrous mounting hardware and accessories to prevent corrosion and discoloration to adjacent materials.

- F. Fixture hardware to comply with the following material standards: For steel and aluminum fixtures, all screws, bolts, nuts and other fastening and latching hardware shall be cadmium or equivalent plated. For stainless steel fixtures, all hardware shall be stainless steel. For bronze fixtures, all hardware shall be stainless steel or bronze.
- G. Doors, frames, and other internal access shall be smooth operating, free from light leaks under normal operating conditions, and designed to permit relamping without use of tools.
- H. Provide supplemental safety device or arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position. Safety devices shall be detachable if necessary and shall not interfere with fixture performance, maintenance, or the seating of any fixture element. Safety device shall not be visible during normal fixture operation and from normal viewing angles.
- I. Luminaires provided must have means for disconnection from power during service, as required in the NEC Article 410.
- J. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 90 %.
 - 2. Specular Surfaces: 90 %.
 - 3. Diffusing Specular Surfaces: 75 %.
 - 4. Laminated Silver Metalized Film: 90 %.
- K. Reflector cones shall adhere to the following criteria:
 - 1. Cones designed for vertically mounted lamps shall provide a minimum of 45 degree cutoff of lamp and lamp image. Cones designed for horizontally mounted lamps shall provide a minimum of 55 degree cutoff of lamp and lamp image. There shall be no visible lamp flashing in the cone.
 - 2. Plastic material shall not be used for reflector cones, unless otherwise specified.
 - 3. Cones shall not be permanently fastened to the housing or ceiling and shall be removable without tools. Retention devices shall not deform the cone or be visible from normal viewing angles.
 - 4. Trim shall be flush to the finished ceiling without gaps or light leaks. Where the flange trim is separate from the cone, it shall have the same finish as the reflector cone.
 - 5. Reflector cones shall be of uniform gauge, not less than 0.032" thick, high purity

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- aluminum Alcoa 3002 alloy. Cones shall be free of spin marks or other defects.
6. Manufacture cone using the Alzak process. Refer to the fixture schedule for cone color and finish (i.e. specular or diffuse) requirements. For compact fluorescent fixtures, finish shall eliminate iridescence.
- L. Lenses, Diffusers, Covers, and Globes shall be 100 % virgin acrylic plastic or annealed crystal glass, unless otherwise indicated.
1. Plastic, polycarbonate and acrylic shall be UV stabilized and shall have high resistance to yellowing and other changes due to aging, exposure to heat and ultraviolet radiation.
 2. Lens Thickness shall be 0.125" (3 mm) unless other thickness is indicated.
 3. Lenses shall have uniform brightness throughout the entire visible area.
- M. Adjustable light fixtures shall have positive locking devices to fix the aiming angle. Fixtures shall be capable of being relamped without adjusting the aiming angle.
- N. Each lighting fixture that has a lamp with an oval shape beam pattern or a spread lens that defines beam orientation shall contain lamp or lens locking devices to insure that lamp or lens orientation is not disturbed during future lamp replacement or cleaning.
- O. All fixtures and ballasts must operate within the temperature limits of their design and as specified by Underwriters' Laboratories, Inc. in the applications and mounting conditions herein specified.
- P. Fixtures recessed in suspended ceilings where the space above the ceiling is either an air supply or return plenum shall conform to NEC Article 300-22.
- Q. Provide plaster frame for recessed light fixtures mounted in other than T-bar ceilings. Verify mounting with architectural reflected ceiling plan before ordering light fixtures.
- R. Provide wire guards on all fluorescent open strip type fixtures.
- S. Air-handling fluorescent fixtures shall be for use with plenum ceiling for air return and heat extraction and for attaching an air-diffuser-boot assembly specified in the Division-23 Section "Air Outlets and Inlets."
1. Air supply units shall have slots in one or both side trims to join with air-diffuser-boot assemblies.
 2. Heat removal units shall have air paths through the lamp cavity.
 3. Combination heat removal and air supply unit shall allow heat to be removed through the lamp cavity at both ends of the fixture door with air supply the same as for air supply units.
 4. Dampers shall be operable from outside the fixture for control of return-air volume.

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5. Static fixture shall have air supply slots blanked off, and fixture appearance shall match that of active units.
- T. For weatherproof or vaportight installations, painted finishes of fixtures and accessories shall be weather resistant enamel using proper primers or galvanized and bonded epoxy, so that the entire assembly is completely corrosion resistant for the service intended. Exterior finishes shall have an outdoor life expectancy of not less than 20 years without any visible rust or corrosion. Where aluminum parts come into contact with bronze or steel parts, apply a coating material to both surfaces to prevent corrosion.
- U. Fixtures for use outdoors or in areas designated as damp locations shall be suitably gasketed to prevent the entrance of moisture. Provide approved wire mesh screens for ventilation openings. Dissimilar metals shall be separated by non-conductive material to prevent galvanic action.
- V. Welding shall be done with electrodes and/or methods recommended by the manufacturers of the metals being welded. Welds shall be continuous, except where spot welding is specifically permitted. Welds exposed to view shall be ground flush and dressed smooth. All welds on or behind surfaces which will be exposed to view shall be done so that finished surface will be free of imperfections such as pits, runs, splatter, cracks, warping, dimpling, depressions or other forms of distortion or discoloration. Remove weld spatter and welding oxides from all welded surfaces.
- W. Electromagnetic-Interference Filters shall be factory installed to suppress conducted electromagnetic-interference as required by MIL-STD-461E. Fabricate light fixtures with one filter on each ballast or driver indicated to require a filter.

2.3 FLUORESCENT FIXTURES

- A. Housing shall be minimum code gauge steel or rigid aluminum construction painted after fabrication with high reflectance white paint unless otherwise indicated in the Lighting Fixture Schedule.
- B. Shielding shall adhere to the following criteria:
 1. Eggcrate louvers shall be aluminum, continuously bound in a perimeter channel frame. Frame, louver, and support shall be painted to a finish as selected by Architect.
 2. Parabolic louvers shall be Alzak aluminum with a low iridescent finish, specular or semi-specular or as indicated in the Lighting Fixture Schedule.
 3. Flat translucent diffuser shall be 100% virgin acrylic and shall have matte finish on exterior side. Diffuser shall be of sufficient density to completely obscure lamp image (min. 0.125" thick).
 4. Flat clear lenses shall be injection molded 100% virgin acrylic or clear tempered glass, thickness as specified in the Lighting Fixture Schedule.
 5. Clear patterned lenses shall be injection molded 100% virgin acrylic. For lenses

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with convex pattern of prisms or cones, specified minimum thickness refers to distance from the flat surface to the base of the pyramids or cones, or to the thickness of undisturbed material. For lenses with concave pattern, specified minimum thickness refers to overall thickness of the material. Lenses shall fully eliminate lamp image when viewed from all directions between 45-90 degrees from vertical. From 0-45 degrees the ratio of maximum brightness to minimum brightness shall not exceed 3:1. Minimum thickness shall not be less than 0.125" with a minimum weight of 8 ounces per square foot.

- C. Doorframes shall be supplied with concealed hinges and latching. Provide mitered corners with no gaps or light leaks.
- D. Lamp mounting shall adhere to the following criteria:
 - 1. Lamps used in rapid start circuits 430 ma and below shall be mounted within $\frac{1}{2}$ " of grounded metal of equal length to the lamp. For lamps operating at 800 ma and 1500 ma, mount within 1" of grounded metal of equal length to the lamp.
 - 2. Provide one grounding lamp holder per lamp for rapid start circuits using single lamp ballasts.

2.4 FLUORESCENT LAMP BALLASTS

- A. General Requirements: Unless otherwise indicated, provide products manufactured by one of the following; Osram/Sylvania, Universal Lighting Technologies, Advance, or approved equal with features that include the following:
 - 1. All ballasts shall be Instant Start or Rapid Programmed Start technology.
 - a. Instant Start ballasts shall be used in fixtures with longer than 3-hour expected time for product to be left on.
 - b. Rapid Programmed Start ballasts shall be used in fixtures controlled by sensors, timers, and/or expected to be turned off and on more frequently than 3-hours or less.
 - 2. Life: Ballasts shall provide normal rated lamp life as stated by lamp manufacturers.
 - 3. Electronic integrated circuit, solid-state, full-light-output, energy efficient type, compatible with lamps and lamp quantities specified.
 - 4. Certifications: Underwriters Laboratories (UL) listed Class P, Certified Ballast Manufacturer (CBM), Electrical Testing Laboratory (ETL).
 - 5. Comply with ANSI C82.11
 - 6. Operating voltage: shall match voltage of circuit. Confirm voltage requirements with Electrical Drawings. Ballasts shall operate lamps correctly within 10% voltage variation without damaging ballasts.

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7. Operating Frequency: 60 Hz at voltage of circuit indicated on drawings.
 8. Lamp Operating Frequency: 20 kHz or higher.
 9. Flicker: Ballasts shall operate lamps with no visible flicker.
 10. Power Factor: 0.95 or higher.
 11. Total Harmonic Distortion Rating: Less than 10%.
 12. Ballast Factor: 0.88 or higher (or as indicated in the Lighting Fixture Schedule)
 13. Lamp Current Crest Factor: 1.7 or less.
 14. Sound Ratings:
 - a. A for 430 ma and 265 ma
 - b. B for 800 ma
 - c. C for 1500 ma
 15. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.
 16. Transient Protection: Comply with IEEE C62.41, Category A or better.
 17. Interference: Comply with 47 CFR, Chapter 1, Part 18, and Subpart C for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
 18. Operating Temperatures: Ballasts shall operate in ambient temperatures up to 105°F (40°C) and shall have thermal protection.
 19. Lamp end of life detection and shutdown circuit.
 20. Automatic lamp starting after lamp replacement.
 21. Single Ballasts for Multiple Lighting Fixtures: Factory wired with ballast arrangements and bundled extension wiring to suit final installation condition without modification or rewiring in the field.
- B. Dimming Ballasts: Comply with general and fixture-related requirements above for electronic ballasts. Unless otherwise indicated, provide products manufactured by one of the following: Lutron or Advance, with features that include the following:
1. Provide ballasts with dimming capability (1%, 5%, 10%) as specified in the Lighting Fixture Schedule.
 2. Compatibility: Certified by manufacturer for use with specific dimming system indicated for use with each dimming ballast.

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3. Ballast shall maintain constant light output for a line voltage variation of +/- 10%.
 4. Ballast shall provide continuous, flicker-free dimming over the entire dimming range.
- C. Low Temperature Ballasts shall be as follows:
1. Temperatures 0°F (Minus 17°C) and Higher: Electronic or electromagnetic type rated for 0°F (minus 17°C) starting and operating temperature with indicated lamp types.
 2. Temperatures Minus 20°F (Minus 28°C) and Higher: Electromagnetic type designed for use with indicated lamp types.
- D. All Luminaires:
1. Comply with IES LM79 and IES LM80 LED product testing procedures, and DOE Energy Star criteria.
 2. Luminaires shall not draw power in the off state. Luminaires with integral occupancy, motion, photo-controls, or individually addressable fixtures with external control and intelligence are exempt from this requirement. The power draw for such luminaires shall not exceed 0.5 watts when in the off state.
 3. Color spatial uniformity shall be within .004 of CIE 1976 diagram.
 4. Color maintenance over rated life shall be within .007 of CIE 1976.
 5. White LED luminaires shall achieve a minimum CRI of 80, and R9 value above 24, and Binning of white LEDs used in the luminaires shall fall within a 3-step MacAdam ellipse minimum, or as indicated in the Lighting Fixture Schedule.
 6. Luminaire manufacturers shall adhere to device manufacturer guidelines, certification programs, and test procedures for thermal management
 7. LED package(s)/module(s)/array(s) used in qualified luminaires shall deliver at least 70% of initial lumens, when installed in-situ, for a minimum of 50,000 hours.
- E. Power Supplies and Drivers:
1. Power Factor 0.90 or higher
 2. Operating temperature: minimum of -20°C or below when used in luminaires intended for outdoor use.
 3. Maximum driver case temperature not to exceed driver manufacturer recommended in-situ operation.
 4. Output operating frequency: 120Hz.
 5. Interference: EMI and RFI compliant with FCC 47 CFR Part 15.

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6. Total Harmonic Distortion Rating: Less than 3%, or as specified in the Light Fixture Schedule.
7. Meet electrical and thermal conditions as described in LM-80 Section 5.0.
8. Primary Current: Confirm primary current with Electrical Drawings.
9. Secondary Current: Confirm secondary current specified by individual luminaire manufacturers.
10. Compatibility: Certified by manufacturer for use with individually specified luminaire and individually specified control components.
11. Solid-state control components to be integral or external per each specified luminaire. Remote control gear to be enclosed in Class 1, Class 2, or NEMA 3R enclosures as required.

F. Controller and Control System:

1. System electronics driver / controller to use coordinated communication protocols: DMX512, 0-10V, DALI, or proprietary as required
2. Contractor to ensure that external control equipment is compatible with LED control requirements
3. Provide connector types and wiring as appropriate for un-interrupted communication between devices, considering distance maximums, field obstructions, and accessibility. Ensure that connection points are optically isolated for system noise reduction.
4. For control components that are part of overall area control system see Electrical Dimming Controls specification.
5. For stand-alone controlled LED systems see the Lighting Fixture Schedule.
6. Compatibility: Certified by manufacturer for use with individually specified luminaire and individually specified power supplies and/or drivers.

2.5 EMERGENCY LIGHTING

- A. Batteries shall be sealed, spillproof, rechargeable, maintenance-free nickel cadmium or pure lead type.
- B. A solid state constant-current charger shall recharge batteries within twenty-four (24) hours of discharge and shall maintain batteries at a fully charged state during normal operation. A low-voltage disconnect shall prevent deep discharge of the batteries.
- C. The inverter unit shall operate one lamp for a period of no less than ninety (90) minutes upon a sustained drop in line voltage to 80 percent of nominal or below.

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- D. A test switch and AC "ON" or unit-ready indicator shall be provided.
- E. Emergency light fixture shall have a minimum lumen output as specified on the drawings.
- F. Exit Signs: Clear or see-through, single-face exit signs, where lettering is visible from the reverse, shall be provided with mirror background inserts.

2.6 LAMPS

- A. Provide products manufactured by one of the following: Osram/Sylvania, General Electric, Philips, Ushio, Venture, or approved equal.
- B. All lamps of the same type are to be provided by the same manufacturer.
- C. Lamp each fixture with the proper quantity of lamps of the type specified in the Lighting Fixture Schedule.
- D. Fluorescent Lamps:
 - 1. All fluorescent lamps shall be tri-phosphor technology.
 - 2. Correlated Color Temperature: 3500 K unless otherwise indicated in the Light Fixture Schedule.
 - 3. Minimum Color-Rendering Index: 85 CRI unless otherwise indicated in the Light Fixture Schedule.
 - 4. Fluorescent Lamps provided are required to have passed Federal TCLP testing.
 - 5. Seasoning: Lamps used in dimmable fixtures shall be seasoned after installation by operating lamps at full output for approximately 100 hours without turning off.
 - 6. Comply with EPA's toxicity characteristic leaching procedure test; shall yield less than 0.2 mg of mercury per liter when tested according to NEMA LL 1.
 - 7. Fluorescent lamps to meet "extra long life".
- E. LED Lamps:
 - 1. See Section 2.3, LED FIXTURES.

2.7 WIRING

- A. All wiring shall be as required by code for fixture wiring.
- B. All flexible cord wiring between fixture components or to electrical receptacles and not in wireways shall have a minimum temperature rating of 105 degrees Celsius.
- C. Cords shall be fitted with proper strain reliefs and watertight entries where required by application.

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- D. No internal wiring shall be visible at normal viewing angles.
- E. For Master/Slave fixtures: Supply ballasts in adjacent fixtures to operate one or more lamps in the adjacent fixtures where required on Electrical Drawings or in the Lighting Fixture Schedule. For single lamp fixtures, provide a two-lamp ballast for two adjacent fixtures. For three-lamp fixtures, provide one two-lamp ballast for the outboard lamps in each fixture and an additional two-lamp ballast for the center lamp in each of two adjacent fixtures.
- F. For Tandem Wired fixtures in continuous rows and where required on Electrical Drawings or in the Lighting Fixture Schedule supply ballasts and wiring to control all inboard lamps together and all outboard lamps together.
- G. Provide #18 AWG, 3 wire flexible conduit connections (whips) for dual level switching as shown on Electrical Drawings for light fixtures recessed in accessible suspended ceiling. Provide 3-wire whips for all dual level switching. Wire count on wire whips is not shown on Drawings and shall be the responsibility of the Contractor to provide proper wire count for the lighting control as shown on Drawings.

2.8 FIXTURE SUPPORT COMPONENTS

- A. Comply with specification sections describing Basic Materials and Methods and Supporting Devices for fixture support and bracing.
- B. Where the ceiling is of insufficient strength to support the weight of the lighting fixtures, provide additional framing from building structure to support luminaires as required. Do not support fixtures from ceiling T-Bar system.
- C. Single-Stem Hangers shall be 1/2-inch steel tubing with swivel ball fitting and ceiling canopy. Finish shall be the same as the luminaire.
- D. Twin-Stem Hangers shall be two, 1/2-inch steel tubes with single canopy arranged to mount a single fixture. Finish shall be the same as the luminaire.
- E. Rod Hangers shall be 3/16-inch minimum diameter, cadmium-plated threaded steel rod.
- F. Wires shall be ASTM A 641/A 641M, Class 3, soft temper, zinc coated steel, 12 gauge.
- G. Wires for humid spaces shall be ASTM A 580/A 580M, composition 302 or 304, annealed stainless steel, 12 gauge.
- H. Hook Hangers shall be integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.
- I. Aircraft Cable Support shall use cable, anchorages, and intermediate supports recommended by fixture manufacturer.
- J. Hangers for Pendant Industrial Fixtures shall be heavy duty No. 8 jack chain with hangers, "S" hooks, mounting, straps, and all required accessories for complete installation.

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PART 3 - EXECUTION

3.1 INSTALLATION

- A. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials. Install lamps in each fixture.
- B. Mounting height indicated in drawings from finished floor to bottom of pendant light fixture or to the center of the outlet box for wall mounted light fixtures unless otherwise noted. Verify mounting heights with Architect and Engineer.
- C. Mounting height may also be indicated as the length of the pendant below finished ceiling.
- D. Provide all necessary hanging or mounting devices and accessories for all fixtures. Verify the types needed for various ceiling conditions. Plaster rings shall be provided where required.
- E. Verify weight and mounting method of all fixtures prior to ordering and provide suitable support. Coordinate with General Contractor for fixtures that require additional blocking or support and provide required support. Fixture mounting assemblies shall comply with all local seismic codes and regulations.
- F. Refer to architectural reflected ceiling plans for coordination of light fixture locations with mechanical and fire safety equipment. Where conflicts occur, coordinate with Architect and Engineer prior to installing any of the systems.
- G. In accessible suspended ceilings, fixture wiring connection, including equipment grounding conductor, shall be through use of 72-inch (max. length) flexible conduit from a rigidly supported junction box, unless noted otherwise.
- H. Wire per requirements of branch circuit installation. Properly ground each fixture.
- I. Light fixtures located in recessed ceilings with a fire resistive rating of 1 hour or more shall be enclosed in an approved fire resistive rated box equal to that of the ceiling.
- J. Install fixtures with vent holes free of air blocking obstacles.
- K. Contractor shall be responsible for adjusting aperture flanges or rings on all recessed fixtures to be flush with the finished ceiling. Fixture trim shall completely conceal ceiling opening.
- L. Adjust variable position lampholders for proper lamp position prior to fixture installation.

3.2 FIXTURE SUPPORT

- A. Comply with specification sections describing Basic Materials and Methods and Supporting Devices for fixture support and bracing.

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- B. Provide all necessary hanging or mounting devices for all fixtures, verify the type needed for various ceiling conditions. Plaster rings shall be provided where required.
- C. Ceiling Fixture Support: Where ceiling is of insufficient strength to support weight of light fixtures installed, provide additional framing from building structure to support as required.
- D. Provide a minimum of two safety wire hangers or threaded rods for each recessed mounted fluorescent fixture. Secure from opposite corners of each fixture and fasten to structure above, independent of ceiling system. Locate supports not more than 6 inches from fixture corners.
- E. Fixtures which are of a size smaller than the ceiling grid shall be located as indicated on the reflected ceiling plans. Fixtures shall be supported independently of the grid ceiling with at least two $\frac{3}{4}$ inch metal channels spanning and secured to the ceiling tees.
- F. Metal decking shall not be pierced for luminaire support.
- G. Where pendants or rods are longer than 48 inches, brace to limit luminaire swinging.
- H. Brace suspended luminaires installed near ducts or other elements so that they do not swing into obstructions.
- I. Wall mounted light fixtures shall be supported from four-square outlet box plaster ring and from wall at non-feed end with two 1/4-inch toggle bolts for gypsum board walls or 1/4-inch bolts to pre-set inserts for concrete wall.

3.3 FLUORESCENT FIXTURES

- A. Recessed Type: Support fixtures independent of the ceiling suspension system.
- B. Fluorescent lighting fixtures shall be switched as shown on electrical drawings. Four-lamp fixtures shown with 2-level switching shall be wired with lamps, 1, 4 and 2, 3 each on separate switch-legs for 2-level switching. Three-lamp fixtures shown with 2-level switching shall be wired with lamps, 1, 3 and 2 each on separate switch-legs for 2-level switching.
- C. If clearance above T-bar system is too restricted to "tip-in" fixture, coordinate with acoustic ceiling installer by leaving one cross T-bar off until the cross T-bar shall be secured into its proper place. Fluorescent fixtures installed in hidden-spline-type ceilings shall have supporting channels installed by Ceiling Contractor to adequately support the fixture without providing additional hangers from the structural ceiling above the suspended ceiling.
- D. Install air handling light fixtures with dampers closed and ready for adjustment.
- E. Install lighting fixture diffusers only after construction work, painting and clean up are completed.

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3.4 LED FIXTURES

- A. Adhere to manufacturers installation guidelines regarding proper thermal management.

3.5 LIGHTING CONTROL

- A. Provide branch circuiting in coordination with lighting control requirements of specification section describing lighting control equipment and as indicated on Electrical Drawings.

3.6 CLEANING AND ADJUSTING

- A. Remove protective plastic covers from light fixtures and fixture diffusers only after construction work, painting and clean-up are completed. Remove, clean, and reinstall all dirty lamps, reflectors and diffusers.
- B. Clean fixtures internally and externally after installation. Use methods and materials recommended by manufacturer for cleaning Alzak reflectors, anti-microbial finishes, and other surfaces.
- C. Make final adjustment of aimable light fixtures and adjustable light settings under the direction of the Engineer during a scheduled period of time prior to the completion of the project, after normal business hours if required. Include all equipment and personnel expenses including overtime required for focusing.
- D. Fixtures, reflectors, and accessories which are damaged, blemished, or impregnated with fingerprints shall be replaced at the contractor's expense. All finishes shall be unmarred upon project completion.

3.7 FIELD QUALITY CONTROL

- A. Coordinate all testing procedures and schedule with the specification section describing Inspections, Testing and Start-up. All testing is to be documented with test procedures, results and initials of witnessing personnel and submitted to the Engineer and included in the O&M Manual.
- B. Coordinate inspection and testing of Lighting Fixtures with specification section for lighting control equipment.
- C. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- D. Replace all burned out lamps or inoperative lamps at the end of construction prior to Owner occupancy.
- E. Advance Notice: Give dates and times for field tests.
- F. Provide instruments to make and record test results.
- G. Test as follows:

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1. Verify proper operation, switching and phasing of each fixture after installation.
 2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation. Verify normal transfer to generator and retransfer to normal.
 3. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to the lighting system, retest to demonstrate compliance with standards.
- H. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

END OF SECTION 265000

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SECTION 27 1000 - TELECOMMUNICATIONS PATHWAYS AND SPACES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Telecommunications Room Build-out
- B. Pathways for Telecommunications Systems
- C. Grounding and Bonding for Telecommunications

1.2 REFERENCES

- A. Industry Codes, Standards and Methods shall be observed, including the following:
 - 1. ANSI/TIA-568.0-D: Generic Telecommunications Cabling for Customer Premises.
 - 2. ANSI/TIA-568.1-E: Commercial Building Telecommunications Cabling Standard
 - 3. ANSI/TIA-568-2-D: Balanced Twisted Pair Cabling and Components Standard
 - 4. ANSI/TIA-568.3-D: Optical Fiber Cabling Components Standard
 - 5. ANSI/TIA-569-E: Telecommunications Pathways and Spaces
 - 6. ANSI/TIA-606-C: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
 - 7. ANSI/TIA-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications
 - 8. ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Cabling Standard
 - 9. ANSI/TIA-4966: Telecommunications Infrastructure Standards for Educational Facilities
 - 10. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition
 - 11. National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)
- B. Comply with all local, state and federal codes for telecommunications installations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements

- 1. Contractor shall outfit all telecom rooms according to T Drawings. Racks and other termination and distribution fields shall be installed according to manufacturer's guidelines and industry standards.
- 2. TR and TER layouts shall be approved by CCPS Technology personnel prior to installation of racks, cabinets, cabling, pathways or termination hardware.

B. Performance Requirements

- 1. Materials and equipment will be installed in an orderly and precise manner. Clearances between equipment will prevent incidental damage or unsafe conditions.
- 2. Equipment shall properly support/house the intended devices per manufacturer's specifications.
- 3. Refer to Telecom Room Details for precise location of equipment and termination fields.

1.4 SUBMITTALS

A. Product Data

- 1. Provide product data for all equipment listed in Part 2
- 2. Equipment data must be submitted in a single package and clearly indicated for efficient review. (by specifications section)
- 3. Equipment must be highlighted with the exact piece of equipment intended.
- 4. Product data must be approved by designer and owner prior to purchase and installation of equipment.

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B. Shop Drawings

1. Provide scaled drawings to show proposed equipment locations, clearances and administrative labeling of Telecom Rooms and associated equipment. All fields, racks and cabinets shall be methodically documented and permanently labeled agreed upon by school district.
2. Shop drawings must be approved by the designer and owner prior to purchase and installation of any equipment.

C. As-Built Drawings

1. Contractor shall, upon completion of the project, provide a complete set of As-Built drawings in hardcopy and electronic CAD format. These drawings shall identify room numbers and outlet identification numbers for all low voltage cabling systems. Drawings should also include all IDF and MDF locations with a detailed layout of all racks, patch panels, trays, and wall fields.
2. Additional project information shall include details of all horizontal and backbone cable routes and pathways.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements

1. All equipment shall be installed in a neat and professional manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the school district. Equipment and materials shall be of the quality indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Substitutions

1. Conditions for consideration of "Or Equal" Products: Where products are specified by name and accompanied by the term "or equal", the proposed "or equal" product will be considered when the following conditions are satisfied.
 - a. If all the following conditions are not satisfied, the Design Consultant will return requests without action, except to record noncompliance with these requirements.
 - b. The proposed product does not require extensive revisions to the Contract Documents.
 - c. With the exception of the product name or number and manufacturer's name, proposed product conforms with requirements indicated on the drawings and in the specifications in every respect and will produce indicated results.
 - d. The proposed product is fully documented and properly submitted.
 - e. The proposed product has received necessary approvals of authorities having jurisdiction.
 - f. The proposed product is compatible with and has been coordinated with other portions of the work.
 - g. The proposed product provides the specified warranty.
2. If the proposed product involves more than one contractor, the proposed product has been coordinated with other portions of the work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.
3. Submission is accompanied with detailed comparison of significant qualities of proposed product with those named in the specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
4. Submission is accompanied with a list of similar installations for completed projects with project names and addresses and names and addresses of design consultants and authorities, if requested.

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5. Submission is accompanied with proposed product's Manufacturer signed written statement on Manufacturer's letterhead, certifying that manufacturer complies with requirements in the Contract Documents.

1.6 WARRANTY

- A. **Warranty:** Installer must provide manufacturer's warranty without cost to the owner during that time period, including materials, hourly costs, etc..
- B. **Installer's warranty shall guarantee workmanship for a period of two years, during which time any deficiency in installation shall be repaired or replaced at no additional cost to the school district. Contractor must respond within 2 business days of written notification.**

PART 2 PRODUCTS

2.1 MATERIALS

- A. **Distribution Racks and Cabinets**
 1. **Floor Mounted 2 Post Free Standing Racks**
 - a. Racks shall be UL Listed and of aluminum construction with a black polyurethane or mil finish. They shall be 84" tall with a minimum 15" base depth. Rack base shall be pre-drilled for securing rack to the floor. Racks shall have 12/24 mounting screws included in the package.
 - b. Rack rails shall be spaced for 19" mounting rail-to-rail and shall be of a U-shaped construction with 12/24 pre-tapped holes in the EIA-310-D standard hole pattern providing 45 rack spaces on both the front and rear. Rails shall have a universal side-drilling pattern to allow racks to be bolted together or attachment of accessories. Racks shall be secured to the floor with anchor bolts.
 - c. Acceptable racks: Ortronics Mighty Mo 6 6.5" deep rack (OR-MM6706) or approved equivalent.
 2. All racks and cabinets shall be capable of supporting the weight and space of existing and proposed equipment. 30% growth capacity shall be provided in addition to detailed requirements.
 3. Racks, cabinets and other termination equipment shall be properly secured to floor with appropriate anchors and bonded to Telecommunications Grounding System.
 4. Provide (1) 8-port transient surge protection strip for each rack in the TER and TRs.
- B. **Cable Management**
 1. **Horizontal Cable Management**
 - a. Horizontal cable management shall occupy 2 rack units, as shown on T Drawings.
- C. **Ladder-Type Aluminum Cable Tray (Ladder Rack)**
 1. All TR and TER locations shall receive ladder-rack style cable tray as shown in T-series drawings for cable distribution.
 2. Class 5160 or Chatsworth "TELCO-Style Cable Runway," 12-inch ladder rack from racks/cabinets from corridor or other wire routing space where indicated on drawings.
- D. **Basket Cable Tray:**
 1. Cablofil EZTray CF 54/300 EZ and CF 105/150EZ
 - a. Cooper B-Line Flex Tray
 - b. Mono Systems Mono Mesh
 - c. Snake Tray
 2. 12" X 2" and 12" x 4" with associated mounting hardware.
 3. Provide runs of cable tray as shown on T Drawings.
- E. **J-Hooks**

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1. Basis of Design: Caddy Cat HP
 - a. Provide 4" (minimum) J-shaped hooks, with smooth beveled edges, for corridor distribution. J hooks for in-room distribution shall be a minimum of 1 5/16" diameter.
 - b. Include all necessary assemblies, hardware, and components for attachment to sidewall, ceiling, or joist.
 - c. J Hooks shall be pre-galvanized steel and UL listed.
 - d. J Hook system shall allow for 20% spare capacity in all cases.
 - e. All manufacturer load and quantity ratings shall be adhered to in all cases.
- F. Conduit
 1. In-wall conduit shall be provided for work in new areas. Refer to T Drawings for conduit details.
 2. Conduit bend radii shall follow current TIA/EIA standards for telecommunications.
 3. Refer to T drawings for locations and sizes of all sleeves for telecommunications.
- G. Gang Boxes
 1. In-wall Gang Boxes for low voltage
 - a. Single Gang Box: Minimum 2.75" wide X 3.75" high X 3" deep with 3/4" and 1" knockouts.
 - b. In-wall Double Gang Box for low voltage: 4 Inch Back Knockout, 4 Inch Side Knockout, 4 Inch End Knockout, Length 3 3/4 Inches, Width 3 25/32 Inches, Depth 3 1/2 Inches or comparable.
 - c. In-wall Deep Double Gang Box.: Raco 259 with six 1-1/4" knockouts.
- H. Distribution Backboard
 1. Plywood
 - a. 3/4" AC-grade plywood shall be provided as shown on T drawing details to line the walls within the TR. The plywood should be provided in 4' x 8' sheets.
 - b. Plywood shall be void free and painted on all sides with two coats of fire-resistant paint.
- I. Electrical Protection for Telecommunications
 1. Telecommunications Main Grounding Busbar (TMGB) and Telecommunications Grounding Busbar (TGB)
 - a. Provide one TMGB in the Telecommunications Equipment Room as shown on T Drawings.
 - b. Provide a TGB in every Telecommunications Room and distribution cabinet location as shown on T Drawings.
- J. Rack mounted power strip
 1. Provide one 12 port transient, surge protection strip (UL Listed) for each rack or cabinet.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Site Verification of Conditions
 1. Contractor shall ensure that sufficient space has been allocated for the installation of all equipment per T Drawings prior to Installation. Clearances and existing equipment should be taken into consideration. If insufficient space exists, the Design consultant should be notified in writing, before proceeding with Installation.

3.2 INSTALLATION

- A. Distribution Racks and Cabinets
 1. Racks shall be assembled such that mounting rails are exactly perpendicular to the base.

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2. Racks shall be secured to the floor using appropriate anchors.
 3. Racks shall be grounded to the TGB or appropriate building ground using a minimum #6 grounding wire.
- B. Distribution Backboard
1. Securely fasten backboard to wall-framing members to ensure it can support attached equipment.
 2. Mount plywood on all available areas where telecommunications equipment may be located.
 3. Refer to T Drawings for minimum coverage.
- C. Ladder Rack and Cable Tray
1. Ladder rack and cable tray shall be properly secured using manufacturer recommended anchors and connectors.
 2. Ladder rack and cable tray shall be routed according to T Drawing floor plans.
 3. Ladder rack and cable tray shall be bonded to ground according to ANSI/TIA 607.
- D. Firestop
1. Provide re-enterable, non-hardening, intumescent putty, rated for floors or wall, UL approved assembly, with approved packing material for fire stopping inside building cable penetrations thru conduits sleeves.
 2. The material used for sealing all openings shall have a fire rating equal to or greater than the floor ceiling, wall or partition material.
- E. Sleeves and openings
1. The telecommunications contractor shall provide sleeves through all walls and floors to protect cabling and or raceways installed as part of the telecommunications system. All sleeves shall extend through the respective wall or partition and finish with a connector protective bushing.
 2. Sleeves through all fire rated structures shall have appropriate fire stop system.

END OF SECTION 271000

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SECTION 27 1250 - STRUCTURED CABLING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Local Area Network (LAN) Cabling
- B. Telephone Cabling
- C. Termination Equipment for Telecommunications

1.2 DEFINITIONS

- A. "Backbone Cabling" refers to telecommunications cabling that provides interconnections between telecommunications rooms, equipment rooms, and entrance facilities.
- B. "Communications Network Outlet (CNO)" refers to a collection of one or more mechanical cable termination device for horizontal cable in the work area.
- C. "Drop" refers to the vertical transition to a location of one or more CNOs.
- D. "Horizontal Cabling" refers to the cabling between and including the work area communications network outlet and the horizontal cross-connect in the telecommunications room.
- E. "Jack" refers to a female-style telecommunication receptacle.
- F. "Telecom Room (TR)" refers to an enclosed space for housing telecommunications equipment, cable terminations, and cross-connects. The room is the recognized cross-connect between the backbone or trunk cabling and horizontal cabling.
- G. "Telecom Equipment Room (TER)" refers to a centralized space for telecommunications equipment that serves the occupants of the building, usually containing the headend equipment for the distribution systems found in the building.

1.3 REFERENCES

- A. Industry Codes, Standards and Methods shall be observed, including the following:
 - 1. ANSI/TIA-568.0-D: Generic Telecommunications Cabling for Customer Premises.
 - 2. ANSI/TIA-568.1-E: Commercial Building Telecommunications Cabling Standard
 - 3. ANSI/TIA-568-2-D: Balanced Twisted Pair Cabling and Components Standard
 - 4. ANSI/TIA-568.3-D: Optical Fiber Cabling Components Standard
 - 5. ANSI/TIA-569-E: Telecommunications Pathways and Spaces
 - 6. ANSI/TIA-606-C: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
 - 7. ANSI/TIA-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications
 - 8. ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Cabling Standard
 - 9. ANSI/TIA-4966: Telecommunications Infrastructure Standards for Educational Facilities
 - 10. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition
 - 11. National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)

- A. Comply with all local, state and federal codes for telecommunications installations.

1.4 SYSTEM DESCRIPTION

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A. Design Requirements

1. LAN and Telephone Distribution:
 - a. Provide labor, materials, equipment, services and operations required for complete installation of LAN compatible with:
 - i. Ethernet 10Base-SX
 - ii. Ethernet 100Base-FX
 - iii. Ethernet 1000Base-SX
 - iv. Ethernet 1000Base-LX
 - v. Ethernet 10GBase-S
 - vi. Ethernet 10Base-LX4
 - vii. Ethernet 10GBase-L
 - viii. Ethernet 10GBase-LRM
 - ix. Fibre Channel 100-MX-SN-I
 - x. Fibre Channel 100-SM-LC-L
 - xi. Fibre Channel 200-MX-SN-I
 - xii. Fibre Channel 200-SM-LC-L
 - xiii. Fibre Channel 400-MX-SN-I
 - xiv. Fibre Channel 400-SM-LC-L
 - xv. Fibre Channel 1200-MX-SN-I
 - xvi. Fibre Chanel 1200-SM-LL-L
 - xvii. FDDI PMD ANSI X3.166
 - xviii. FDDI SMF-PMD ANSI X3.184
 - b. All wiring including copper and fiber optic employs a star topology.
 - i. Category 6 UTP wiring terminates on Category 6 RJ-45 jack at workstation and on Category 6 rack-mounted patch panel in telecommunications room. Connections wired per ANSI/TIA-568C.
 - ii. Category 5e UTP wiring terminates on Category 5e RJ-45 jack at workstation and on wall mounted 110-block in telecommunications room. Connections wired per ANSI/TIA-568C.
 - iii. Fiber optic cable connects distribution racks between telecommunications rooms and terminates on rack-mounted fiber optic patch panel.
 - c. Network cables routed from distribution racks throughout building as shown on T-Drawings. Drop to outlet installed in conduit and wall box, or dual-channel surface mounted raceway to communications outlet in classrooms, offices, or other locations indicated on T-Drawings.
 - i. Refer to notes on each drawing to determine exact installation methods.
 - ii. Note and record all cable lengths to the nearest foot.
 - iii. Replace any cable exceeding 90 meters (295 feet) and route to reduce length to a minimum of 90 meters. Complete all cable rerouting for compliance at no additional cost to School district.
 - iv. Identify to Design consultant prior to installation of any cables that cannot be reduced to 90 meters or less in total length (rise and run).
 - v. Strictly adhere to most current version of ANSI/TIA Telecommunications cabling standards.
 - vi. Unless otherwise noted on T-Drawings, provide ladder-type cable tray from corridor to distribution racks and termination fields in telecommunication rooms.
 - vii. Install "waterfall" device providing sweep from cable tray to data rack/cabinet and other vertical transitions.
 - d. Data outlets: Category 6 rated RJ-45 type connectors with all four copper pairs terminated and tested in accordance with ANSI/TIA 568C wiring standard.
 - e. Telephone outlets: Category 5e rated RJ-45 type connectors with all four copper pairs terminated and tested in accordance with TIA 568B wiring standard.
 - f. Fiber Optic Horizontal and Backbone Cables: Terminate on panels in each rack and utilize SC-type connectors with ceramic sleeves. Terminate and test all strands unless otherwise noted.

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- g. Permanently identify and label all cables and termination devices, at distribution rack and workstation in accordance with ANSI/TIA-606 Standard or as agreed by Design consultant and school district.
 - h. Remove and replace any cables failing to meet end-to-end testing requirements; do not abandon cable in place. All cable shall be terminated at both ends, unless noted in T-Drawings.
- B. Performance Requirements
1. Comply with applicable requirements in Local, State and Federal Codes, ANSI/TIA Standards, and BICSI methodology.
 2. Provide all work, materials, and manner of placement in strict accordance with requirements of latest edition of National Electrical Code.
 3. Provide all materials listed as complying with available standards of Underwriter's laboratories or other similarly established standards and carry their label. Apply all materials in strict accordance with Underwriter's laboratories listing.
 4. All work described in this Section performed by Contractor or approved qualified subcontractor.

1.5 SUBMITTALS

- A. Comply with requirements of Division 0 and Division 1 - Submittals and as modified below.
- B. Product Data: Submit manufacturer's product literature, technical specifications and similar information for the following items demonstrating compliance with the specified requirements.
 1. Communications outlets, faceplates, and accessories.
 2. Fiber optic cable, patch cables and terminations.
 3. Copper cable, patch cables and termination devices.
 4. Inner duct and accessories.
 5. Rack configurations and wiring diagrams.
 6. Network cabling test equipment and process (routines).
 7. Coaxial Homerun Cable
 8. Equipment Racks
 9. Wall outlets
- C. Samples: Provide samples of outlets and assemblies as described below, prior to installation, for approval by designer.
 1. Telecommunications outlets – Submit samples of telecommunications outlets to be provided including following components and characteristics:
 - a. Flush mounted and Raceway outlets – Completely assembled faceplate and wall box with each type of outlet to be mounted in faceplate, including blank covers, dust covers, labeling field, cabling, and adapter plates and bezels required.
 - b. Sample characteristics:
 - i. Provide all components in colors selected by Design consultant.
 - ii. Provide multiple outlet samples where required to accurately represent range of outlets to be provided.
- D. The Contractor shall submit line drawings of all systems showing major components of the systems. Submit wiring diagrams showing typical connections for all systems and equipment.
- E. Quality Control Submittal
 1. Test Reports: Submit complete sample test data and reports with exact labels used on cables, patch panels and faceplates.
 2. Certificates
 - a. Manufacturer Certification: Submit certification from manufacturer of products to be installed under this contract certifying that Installer is authorized by manufacturer to install specified products.

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- b. Installer Experience Listing: Submit list of at least 5 completed projects as specified below in "Quality Assurance – Qualifications – Installer."

F. Permits

- 1. All necessary permits will be submitted to CCPS prior to beginning work.

G. Contract Closeout Submittal: Comply with requirements of Division 0, including submission of operating and maintenance instructions as item in "Operation and Maintenance Data" manual described in that Section.

1.6 QUALITY ASSURANCE

A. All Work shall be installed in a first class, neat and workmanlike manner by skilled Technicians. The quality of the workmanship shall be subject to inspection and approval by authorized school district personnel. Any work found to be of inferior quality and/or workmanship shall be replaced and/or reworked until the approval of school district is obtained.

B. Installer Qualifications: Qualified to cable, terminate and test data network cabling system specified in this Section, certified by manufacturer of products to be installed, and completed at least 5 computer network installations of similar size, nature and complexity as specified for this project.

C. Conditions for Consideration of "Or Equal" Products: Where products are specified by name and accompanied by the term "or equal", the proposed "or equal" product will be considered when the following conditions are satisfied. If all the following conditions are not satisfied, Design Consultant will return requests without action, except to record noncompliance with these requirements:

- 1. Proposed product does not require extensive revisions to the Contract Documents.
- 2. With the exception of the product name or number and manufacturer's name, proposed product conforms with requirements indicated on the Drawings and in the Specifications in every respect and will produce indicated results.
- 3. Proposed product is fully documented and properly submitted.
- 4. Proposed product has received necessary approvals of authorities having jurisdiction.
- 5. Proposed product is compatible with AND has been coordinated with other portions of the Work.
- 6. Proposed product provides specified warranty.
- 7. If proposed product involves more than one contractor, proposed product has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.
- 8. Submission is accompanied with detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
- 9. Submission is accompanied with a list of similar installations for completed projects with project names and addresses and names and addresses of design consultants and authorities, if requested.
- 10. Submission is accompanied with proposed product's Manufacturer signed written statement on Manufacturer's letterhead, certifying that manufacturer complies with requirements in the Contract Documents.

1.7 WARRANTY

A. Installer's Warranty: Provide manufacturer's system warranty against electrical or mechanical defects for 2 years from date of final acceptance.

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- B. A fifteen (15) year Extended Product Warranty and Systems Assurance Warranty for this wiring system shall be provided by the Manufacturer as follows:
1. Extended Product Warranty: The Extended Product Warranty shall ensure against product and workmanship defects, that all approved cabling components exceed the specifications of ANSI/TIA 568 for fiber link/channels and copper components, for a fifteen (15) year period. The warranty shall apply to all passive components, including both cable and connecting hardware as a combined system. Any claims cover replacement costs on any defective product, both material and labor. Extended warranties beyond fifteen (15) years will be considered.
 2. System Assurance: The System Assurance shall cover the failure of the wiring system to support the application which it was designed to support as well as additional application(s) introduced in the future by recognized standards or user forums that use the ANSI/TIA 568C component and link/channel specifications for cabling, for a fifteen (15) year period.
 3. System Certification: Upon successful completion of the installation and subsequent inspection, the School district shall be provided with a numbered certificate, from the manufacturing company, registering the installation.

PART 2 PRODUCTS

2.1 MATERIALS

- A. All materials shall be new and unused except as noted in T-series Drawings.
- B. Copper Cabling Components for LAN and Telephone Distribution
 1. LAN Horizontal Data Cabling
 - a. Requirements: Complete balanced, twisted-pair compliant with current Category 6/6A provisions under ANSI/TIA 568C Telecommunications Cabling Standard, including but not limited to:
 - i. "Component compliant" components certified to meet all requirements of ANSI/TIA-568-C.2 "Balanced Twisted Pair Cabling Components."
 - ii. After assembly into completed cabling channel, all components meet performance requirements as specified in ANSI/TIA-568-C.1 and C.2, meet cable manufacturer's and outlet manufacturer's performance requirements and are performance certified for Category 6 as a complete channel system.
 - iii. Shall meet specified physical and transmission characteristics requirements.
 - iv. Exceed minimum performance requirements of ANSI/TIA-568-C by significant margin. Cabling solutions not demonstrating significant margin are not acceptable.
 - b. Physical Characteristics
 - i. 100 Ohm Category 6 Unshielded Twisted Pair Cable (UTP)
 - ii. Meeting requirements of ANSI/ICEA S-80-576. For cables not specified in "Approved Components" paragraph, all 4 pairs insulated with F.E.P. providing maximum 0.023-inch diameter of insulated conductor.
 - iii. Data cable shall be blue in color
 - iv. Acceptable Cable
 - (a) Berk-Tek 10033817(PVC)-Cat 6
 - (b) Or Approved Equivalent
 - v. Consists of four 22 - 26 AWG twisted pairs.
 - vi. Cable shall be plenum or non-plenum as required by code.
 - vii. Color coding of pairs:
 - (a) Pair 1.....W-BL; BL
 - (b) Pair 2.....W-O; O
 - (c) Pair 3.....W-G; G
 - (d) Pair 4.....W-BR; BR

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- viii. Overall diameter not exceeding 0.250 inches for a single cable.
- ix. Ultimate Breaking Strength (ASTM D 4565): 400 N minimum
- x. Withstands 1-inch bend radius at -20 degrees Celsius without jacket or insulation cracking.
- c. Third-party verified to meet ANSI/TIA Category 6 requirements. All completed cabling channels fully backwards compatible with requirements of Category 5 and 5e cabling systems.
- d. Transmission Characteristics
 - i. DC resistance of any conductor not exceeding 9.38 Ohms per 100m max. at 20 degrees Celsius measured in accordance with ASTM D4566.
 - ii. Mutual capacitance of any pair at 1 kHz for 100 m. of cable not exceeding 5.6nF.
 - iii. DC resistance unbalance between any two conductor of any pair not exceeding 5 percent when measured at or corrected to 20 degrees Celsius in accordance with ASTM D 4566.
 - iv. Capacitance unbalance to ground at 1 kHz of any pair not exceeding 330 pF per 100 m.
 - v. Delay skew not exceeding 25 ns at 100 MHz.
 - vi. Propagation delay of any pair at 10 MHz not exceeding 5.7 ns/m.
 - vii. Maximum Attenuation of any pair not exceeding values given in ANSI/TIA-568-B.2-1.
 - viii. NEXT coupling loss, PSNEXT loss, ELFEXT loss, PS-ELFEXT loss and Return Loss meeting requirements of ANSI/TIA-568-B.2-1.
- 2. Patch Panels for LAN Cabling
 - a. Shall meet requirements for category 6/6A (per SCHOOL DISTRICT standards) performance requirements.
 - b. Panels shall contain the number of termination ports required to terminate all LAN and telephone jacks in service area, plus 20% spare capacity.
 - c. Acceptable units:
 - d. OR-PHD6E6U xx (24 or 48 cat 6/6a)
 - i. Or approved equivalent.
- 3. Patch Cables for LAN and Telephone Cabling
 - a. Factory terminated and tested UTP patch cables at workstation and equipment cross-connect meeting requirements of ANSI/ANSI/TIA-568-C for patch cable testing.
 - i. Meet all requirements of ANSI/ANSI/TIA-568-C.2 standard.
 - ii. Contact plating of minimum of 50 micro inches of gold in contact area over 50 micro inch of nickel, compliant with FCC part 68.5.
 - iii. Use 8-position connector, unkeyed.
 - iv. Modular connector maintaining paired construction of cable to facilitate minimum untwisting of wires.
 - v. Factory assembled and constructed to 100 ohm, 4-pair UTP per ANSI/ANSI/TIA-568-B for minimum, Category 6 compliance.
 - vi. Performance marking indelibly labeled on jacket by manufacturer.
 - vii. Accepts color-coded labels to comply with ANSI/TIA-606 labeling requirements at both ends.
 - viii. Manufactured by ISO 9001 Company.
 - b. Patch cords shall be light grey in color and without boots.
 - c. Patch cords for wireless shall be Purple.
 - d. Patch cords for CCTV shall be blue.
 - e. Patch cord length shall be as follows: (note: Owner shall determine patch panel port end)
 - i. LAN outlet, station end shall be 14 feet.
 - ii. Patch Panel port end shall be (50%) at 3 feet, and (50%) at 5 feet.
- 4. Analog Backbone Cables:
 - a. Category 5e grade premises cable

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- b. 24AWG solid bare copper conductors
 - c. Multi-pair cable bundled in 25-, 50-, 100-pair groups.
 - d. Acceptable Cables
 - i. Mohawk P/N M58141 – Non-Plenum
 - ii. Or Approved Equivalent
 - e. T-1 Extension Cable: If Telephone Company demarcation needs to be extended to interior location, provide multi-pair voice grade cable of 25 or more pairs, similar to Lucent "CMP-002524SAS-and dual screened 4-pair T-1 circuit rated cable, similar to Lucent "CMP-00822-T1-3".
 - i. Place cable from point of demarcation to cross connect terminal blocks serving CO connections.
 - ii. Refer to specific requirements.
 - 5. LAN and VoIP Jacks
 - a. Must meet category 6 performance criteria.
 - b. Non-keyed Rj-45 style modular jack with compatible faceplate.
 - c. Cables shall be terminated using the T568B wiring standard.
 - d. Modular jacks shall be the following color, based upon usage:
 - i. Telephone Jack
 - ii. LAN Jack
 - e. Acceptable Jacks
 - i. Ortronics
 - ii. Or Approved Equivalent
 - 6. Faceplates
 - a. All faceplates shall have a clear plastic window for labeling.
 - b. Shall accept inserts for Telephone, LAN, Video, Fiber Optic, Video Distribution, etc...
 - c. Refer to T-series drawings for CNO configurations and provide appropriate faceplate.
 - d. Faceplates shall fit standard electrical outlet boxes and/or Wiremold style dual-channel raceway where shown on T-drawings.
 - e. Provide sufficient blank covers for all unused ports. Provide dust covers for all terminations.
 - f. Acceptable Manufacturers
 - i. Ortronics
 - ii. Or Approved Equivalent
- C. Fiber Optic Cabling Components
- 1. Used as backbone cable, connecting all Telecommunications Rooms, trunk cable for interconnecting Telecommunications Equipment Room to telecom utility company interface, and trunk cable connecting buildings on campus-wide data distribution system. Provide cables with actual fiber type and count as specified in plan and riser T-Drawings.
 - 2. Cable Type
 - a. Cable shall be plenum or non-plenum as required by code.
 - b. Multimode Cable shall have aqua colored exterior jacket and single-mode cable shall have yellow exterior jacket.
 - c. All horizontal and vertical fiber runs shall be enclosed in approved "inner duct" or conduit its entire length to protect cable from damage.
 - d. At each end of the fiber cable, slack (15 to 30 feet) shall be left to facilitate reasonable future relocation of the fiber. Slack shall be mounted on wallboard or cable trays according to SCHOOL DISTRICT instruction.
 - e. Single-mode Fiber Optic Strands: 8-9/125 microns core/cladding single-mode glass fiber.
 - i. Standards
 - (a) UL listed for plenum use; meeting NEC, Article 770 – Optical Fiber Cables and Raceways and passed UL 910 flame test.
 - (b) Tight-buffered fibers color-coded in accordance with ANSI/TIA-598 "Color Coding of Fiber Optic Cables."

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- (c) Single-mode fiber utilized in optical fiber cable meeting ANSI/TIA-492CAAA, "Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers," and ITU recommendation G.652, "Characteristics of Single-Mode Optical Fiber Cable."
 - ii. Fibers: Meet ANSI/TIA 455-45A, 45A "Microscopic Method for Measuring Fiber Geometry of Optical Waveguides" for single-mode fiber optic cables.
 - iii. Meets or exceeds all attenuation values given in ANSI/TIA-568C.3 and Addenda.
 - iv. IEEE 802.3z Performance: Supports laser-based GbE operation in 1000BASE-LX (1300 nm) operating window at 5000 m.
 - v. Macrobend Attenuation: Attenuation due to 100 turns of fiber around 75 +/- 2 mm diameter mandrel not exceeding 0.05 dB at 1310 nm and 0.10 dB at 1550 nm.
 - vi. Maximum Dispersion: Less than or equal to 3.55 ps/(nm·km) from 1285 nm through 1330 nm and greater than 18 ps/(nm·km) at 1550 nm.
 - vii. Fiber Curl: Greater than or equal to 2.0 m radius of curvature.
 - viii. Cable Operating Temperatures
 - (a) Indoor Cable: -20 degrees Celsius to 70 degrees Celsius.
 - (b) Outdoor Cable: -40 degrees Celsius to 70 degrees Celsius.
- f. Terminations
- i. All terminations on single-mode optical fibers factory-made using machine polished process and exhibiting minus 45 dB or better back reflection after being fusion-spliced to cable strands in field; similar to factory-manufactured, pre-terminated single-mode pigtail assemblies by Corning/Siecor.
 - ii. Provide additional components such as fan-out kits, buffer tubes, and similar components where required for proper termination of cable.
 - iii. Connectors shall be SC-type.
3. Fiber Patch Panels and Wire Management Components
- a. Refer to T-Drawings for direction on what style patch panel and wire management to provide.
 - b. Rack Mounted High Density Fiber Optic Connector Housings and Patch Panels
 - i. Manufacturers – For convenience, details and specifications based on:
 - (a) High Density 24, 48 and 72 Port Panels by Ortronics
 - (b) OR-FC02U-M
 - (c) OR-FC04U-M
 - ii. Rack Mounted unit, suitable for standard 19-inch equipment rack, providing interconnect between horizontal wiring and patch cable to wiring hub and equipped with smoked Plexiglas door with metal trim and lock.
 - iii. Housings mounted in EIA-310 compatible 465 or 592 mm rack and available in several sizes, including 1U, 2U, 3U and 4U.
 - (a) One EIA rack space or panel height (denoted as 1 U) defined as 44.45 mm in height.
 - iv. Modular unit with separate splicing, connector and jumper management and combination connector/splicing housings available.
 - v. High density multiple fiber cabinet housing with slide-out drawers, providing exact quantity of multimode/single mode connectors required to terminate all fiber optic strands for each fiber optic cable at each rack, plus 20 percent spare for future expansion, including ceramic connector sleeves.
 - vi. Housing includes provisions for mounting fiber fan-out devices required to build 250-µm for fiber protection and to allow direct connectorization.
 - vii. Brackets included, allowing wall mounting of rack mount hardware with space for jumper management panels.

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- viii. Provide patch panels at each location to accommodate total number of incoming cables being terminated with 20 percent spare capacity for future expansion.
- ix. Properly identify single-mode and multimode terminations.
- c. Surface-Mounted Fiber Connected Housings
 - i. Manufacturers – For convenience, details and specifications based on:
 - (a) Pre-Assembled with SC-Connectors: Ortronics
 - (b) Corning Cable Systems
 - ii. Multiple ports designed for wall-mount applications to enclose patching, splicing or demarcation of single-mode or multimode fibers and provide for direct connectorization or pigtail splicing.
 - iii. Provide wall-mount connector housing in connector panel version to provide for varying fiber counts and meeting functional requirements specified in "Connector Panels" subparagraph.
 - iv. Standard connector housing configured for direct connectorization with provision for mounting fiber fan-out devices incorporated into housing. Fiber fan-out devices build 250 µm fiber in buffer tubes out to 900 µm for fiber protection and to allow connectorization.
 - v. Unit mountable on standard plywood walls.
 - vi. Housings manufactured using minimum 16-gauge aluminum or equivalent for structural integrity and finished with wrinkled black powder coat for durability. Assembly hardware and equipment attaching machine screws to match finish.
- d. Connector Panels
 - i. Manufacturers: For convenience, details and specifications based on "CCH-CP12-xx" for 12 fiber adapter panels by Corning Cable Systems.
 - ii. Multiple port designed for patching, splicing, or demarcation of single-mode or multimode fibers.
 - iii. Rack and wall-mountable connector housings accept interchangeable connector panel defined as modular removable plate containing optical fiber connector adapters or copper jacks.
 - iv. Utilizes single mounting footprint with multiple connector adapters in each panel. Interchanges between rack- and wall-mountable hardware.
 - v. Provide ceramic connector sleeves.
 - vi. Provide industry standard single fiber and small form factor multi-fiber adapters, including SC-duplex, ST-, FC-, and MT-RJ connectors as necessary.
 - vii. Blank connector panels provided to fill unused space within housings attached with at least two push-pull latches allowing quick installation and removal. Housings supplied with blank connector panels for all available positions unless housing ordered with optical fiber adapters pre-installed.
- e. Wire Management Panels
 - i. Horizontal – Wire Management: Black, rack-mounted, 2U, Part # OR-808004410.
- 4. Fiber Optic Patch/Jumper Cables: Factory assembled optical fiber assemblies with SC to LC-connectors. Exact lengths determined in field and based on actual rack layouts, to provide manageability and orderly appearance. Provide exact quantity as required to patch all rack-terminated ports to network electronics ports, plus 10 percent spare. Provide ceramic connector sleeves.
 - a. Cable length: 2 meters long, unless otherwise specified. Verify quantity and length at time of installation. Replace with shorter or longer cable at no additional cost to School district.
 - b. Single mode patch cables shall be yellow.
 - c. Provide all jumpers conforming to ANSI/TIA 568-C Standard.

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PART 3 EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: Examine conditions under which telecommunications cabling and equipment and related components are to be installed in coordination with Installer of materials and components specified in this Section and notify affected Prime Contractors and Design consultant in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected to ensure a safe and timely installation.
1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Design consultant written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.
 2. Visit Site to identify and become familiar with existing field conditions and specific requirements of each Site.
 3. Verify all dimensions in field and confirm condition of existing hardware to be utilized.
 4. Confirm space requirements and physical confines of all work areas to ensure that all materials can be installed in indicated spaces.
 5. Confirm all outlet locations and cable pathways and advise Design consultant in writing of any discrepancies or issues in Design described in Contract Documents.

3.2 PREPARATION

- A. Protection: Provide adequate protection of equipment and hardware before and after installation.
- B. Existing Communications Services: Ensure all telecommunications systems (voice, video and data) remain operational throughout the project.
1. Identify any additional telecommunications outlets, circuits, and wiring at the site not shown on T-Drawings and interfering with installation of specified equipment.
 2. Contact local telephone, network and CATV companies to identify all circuits providing existing services.
 3. Remove all accessible portions of abandoned communications cabling per NEC 800.52. Tag all communications cabling not terminated at both ends but retained for future use.

3.3 INSTALLATION

- A. Provide and install all components necessary to install complete telecommunications cabling and equipment systems, including (but is not limited to) connectors, patch cables, terminators, etc...
1. Cable runs shall be continuous and unbroken from end to end. Splicing of any Telephone, LAN, or coaxial video distribution cable is prohibited. Horizontal cabling for LAN and telephone shall end in rack-mounted patch panels.
 2. Secure all horizontal cables within ceiling cavities to building structure.
 3. Loosely bundle all cables and support from structure at unequal intervals from 5 to 6 feet with spring steel fasteners and cable clip rated for use with high performance cables where cable tray or other support structure has not been provided as indicated on Drawings. All mounting clips shall be seismic type as per BOCA.
 4. Do not violate manufacturer's recommended loadings. Leave 30% capacity for future use of pathway.
 5. Verify all horizontal cable run lengths prior to installation. Re-distribute horizontal cabling to maintain distance requirements and maintain pathway route accessibility.
 6. Do not support cables from ceiling grid T-Bars, grid wire supports or bridle rings. Do not allow cables to touch ceiling grid.

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7. Do not secure cables with permanent cable ties. Do not tighten cable bundles in such a way as to cause jacket deformation or damage.
 8. Provide a 10-foot service loop in all fiber optical cables to permit future cable splice and repair at all building entrance points and termination points.
 9. Place cables in compliance with ANSI/TIA-568.C standards and BICSI recommended methods.
 10. Tight 90-degree bends are unacceptable and use of plastic "cinch-type" tie-wraps are not permitted, in order to prevent damage to cable jacket and compromise the cable's electrical or optical characteristics.
 11. Cable bundles shall be neatly routed with a service loop to provide 10 feet of slack at the cross-connect end and as noted in the T-drawings. Cable bundles shall be secured using only black Velcro cable wraps.
 12. 10 feet of service loop shall be provided in the ceiling at each workstation. Contractor shall not secure service loop in coils, but route in such a manner as to minimize EMI.
 13. Wireless outlet locations
 - a. Wireless locations shown on T-series drawings shall be installed outside of a faceplate.
 - b. Ceiling shall be marked and as-builts shall reflect the location of all terminated ends and service loops as directed by SCHOOL DISTRICT personnel.
 - c. Cable shall be terminated in a female RJ-45 female jack and left with a service loop as described in T-series drawings. Cable shall be tested and documented per previous requirements.
 - d. After completion of wireless site survey, outlet shall be re-terminated for connection to Wireless Access Point.

B. Determine allowable cable proximity to other electrical power sources of 480 Volts or less using ANSI/TIA-569A "Cabling Pathway Standard" for UTP cable separations from sources of EMI:

CONDITION	< 2kVA	2-5 kV	> 5 kVA
a. Unshielded power lines or electrical equipment in proximity to open or non-metal pathways	6 in.	12 in.	24 in.
b. Unshielded power lines or electrical equipment in proximity to open or non-metal pathways	3 in.	6 in.	12 in.
c. Power lines enclosed in a grounded metal conduit (or equivalent shielding) in proximity to grounded metal conduit pathway	3 in.	6 in.	12 in.
d. Transformers & Elec. Motors	40 in.	40 in.	40 in.
e. Fluorescent Lighting	12 in.	12 in.	12 in.

C. Interior Fiber Optical Cable Installation Requirements

 1. Install all interior fiber optic backbone cables in 1-inch plenum-rated inner duct, similar to Pyramid Industries #PLM100(T) where fiber optical cable placed in cable tray or otherwise fully supported in accordance with manufacturer's requirements.
 2. Install all outdoor rated communications cables not rated for plenum placement in interior environments in metallic conduit, according to NEC Articles 770 and 800.
 3. Install inner duct for fiber optic cabling in all conduits, as necessary for proper support of cables, or where required to assure pull-in tension not exceeding manufacturer's recommendations.
 4. Provide pull strings or ropes in all conduit and inner duct used for communications cables.

D. Video Distribution Cabling System

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1. Where not provided as part of the electrical work or the data/voice work, the Contractor shall furnish and install necessary conduit, raceways, pull boxes, outlet boxes and cable to provide a complete system as herein specified. All wiring shall be tested for continuity and freedom of all grounds and short-circuits. All outlet boxes shall be as specified for other wiring devices; size as required by equipment manufacturer.
 2. Cables shall be installed in raceways or EMT, as detailed on the drawings and/or as specified, above non-accessible ceilings, where exposed, and wherever it may be subject to physical damage. Where not provided as part of the electrical work or the data/voice work, the Contractor shall provide a raceway (conduit) from each outlet to above the accessible ceiling. Otherwise, cable shall be installed above accessible suspended tile ceilings and attached to building structure with approved bridle rings or J-hooks, cable is not permitted to rest on ceiling. The cable routes used shall avoid steam lines, power wiring and other utilities that may adversely affect the system's performance or result in damage to the cable. If the routes required place the cable in proximity to these utilities, the cable shall be suitably protected. Under no circumstances shall cable be run in hangers used for pipes or electric conduits nor shall the cable be supported in any way by attachment to these pipes, conduits or ceiling hangers.
 3. During the installation work, improper bending, stretching, twisting, kinking, pinching or any other improper handling must not deform the cable. All cable runs shall contain "S" loops or other means to accommodate expansion and contraction. Coaxial cables shall not bend at any point of installation to a radius of less than ten times the diameter of the cable or less than the value recommended by the cable manufacturer. Cable connected to electronic equipment in the system shall be tagged to show its function and the location of its other end. All labels shall be of durable material and securely fastened to the cable.
 4. All cables shall be fastened securely with suitable hardware so as to avoid sharp bends and to prevent rubbing against sharp corners and in a manner to prevent injury or physical distortion.
 5. All connections shall be made with suitable connectors only at a known point or where otherwise indicated on the drawings to facilitate later system servicing. There shall be no splicing of coaxial cables.
 6. All coaxial cables shall be installed in a manner to prevent sharp bends and pressure points that may cause the cable to lose its concentricity due to core migration. Particular care shall be taken where bridle rings are used.
 7. Wiring for all wall-mounted equipment shall be concealed in raceway (conduit) from outlet to above removable ceilings, unless noted otherwise.
 8. Wiring installed above removable ceilings shall be installed on bridle rings. No cables shall be installed on roof or exterior of building.
 9. Infrastructure properly terminated on backboard, neatly arranged in orderly fashion and accurately identified.
 10. Equipment cabinet(s) anchored to wall or floor utilizing an approved method.
 11. Install all exposed cabling in surface raceway by Wiremold, Hubbell or Panduit where in-wall conduit has not been provided. Follow all manufacturers' guidelines requirements regarding bending radius and slack. All bends, offsets and fittings shall be appropriately sized to provide 30% capacity after installation.
- E. Install all cable in accordance with National, state and local codes and ANSI/TIA Standards, and BICSI methods.
1. Follow manufacturer's guidelines and requirements for all cable termination.
 2. Install and connect #6 AWG to bond all equipment racks, conduits and cable trays to busbar in each telecom room. Each telecom room shall be interconnected to TER with #3 AWG bonding backbone to TMGB per Telecommunications Grounding Diagram. It shall be left to licensed electrician to interconnect TMGB with lowest point of building ground. Contractor shall verify TMGB has been bonded to building ground before declaring completion.

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- F. Permanently identify all system components following ANSI/TIA-606A "Administration Standard for Commercial Telecommunications Infrastructure" with identification format:
1. Identification: Provide permanent identification labels for outlets, faceplates, patch panels, access panels and entrance facilities.
 2. Each individual cable shall be labeled on both ends of cable terminations regardless of cable intended use. Labels must be machine printed with permanent black ink on laminated white label material. Contractors must check with appropriate school district personnel for appropriate labeling scheme. The intended format and labeling material must be approved by school district Technology Department before labeling begins.

3.4 TESTING

- A. LAN, Telephone and Video Cabling System
1. Upon completion of work, all parts of the telecommunications installation shall be tested by the Telecommunications Contractor and demonstrated free of any defects. Preliminary testing will be permitted but shall not be accepted in lieu of obtaining final test results. Final test results shall be accomplished by the use of proper test equipment for the system being tested.
 2. Full end to end link testing shall be performed on all pairs and include
 - a. Continuity, opens, shorts, reversed, transpositions and split pairs
 - b. Length
 - c. NEXT & FEXT
 - d. Attenuation
 - e. Crosstalk / Alien cross talk
 3. Cable tester must be a minimum Level III type.
 4. Re-terminate and re-test any cables or pairs of cables failing end-to-end testing requirements. Replace any faulty cables/pairs or termination devices. Remove all defective cables completely from pathways.
- B. As-Builts
1. Accurate as-built drawings shall be provided in electronic and hard copy format.
 - a. Drawings shall accurately show and describe all cable routing and equipment location in redline format.
 - b. 3 copies of electronic (CAD) drawings shall be distributed on appropriate media: 1 to construction management, 1 to designers and 1 to the school district.
 - c. 3 hard copies of CAD drawings shall be plotted on full size sheets and test results of every installed cable have been given to the construction management for appropriate distribution.

3.5 ACCEPTANCE

- A. Contractors work shall be considered complete after the following conditions have been met:
1. Cable installation is complete and all cable runs have been tested and documented to be installed according to specifications and drawings.
 2. A school district Technology representative has successfully tested the "LIVE" system.
 3. All punch list items have been reconciled.
 4. All disturbed ceiling panels, firestopping materials, covers, etc. have been properly reinstalled.
 5. All materials and trash have been removed from the site.
 6. 1 Hardcopy and 1 softcopy of approved cable test results have been submitted.
 7. A 2-Year Installers warranty has been given to a school district Technology representative.
 8. As-builts and Record drawings have been submitted.
 9. Submit Manufacturers Extended Warranty Application.

END OF SECTION 271250

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SECTION 27 5000 – INTERCOM AND CLOCKS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

1. This section and associated drawings define a communications system for an intercom, public address and clock system. The contractor shall provide all infrastructure, cable, hardware and equipment as defined to provide a complete and operational system.

1.2 SYSTEM DESCRIPTION

A. Design Requirements

1. Intercom/PA/Clock System

- a. The facility intercommunication system shall be a low voltage system that utilizes a copper cable infrastructure to distribute a user-defined input in a single or bi-directional manner. The system shall be capable of multiple, simultaneous conversations on separate channels throughout the facility through telephones and loudspeaker assemblies.
- b. A programmable master for tone distribution schedule shall also be included as part of the overall system.
- c. The system shall be microprocessor based and have the ability to interconnect with the telephone system installed within the facility if future connection is required. In addition, the system must be expandable to meet the user's future expansion needs and be programmable from a computer terminal located at the facility.
- d. The system shall include an override of auxiliary sound equipment to work through the auxiliary sound speakers.
- e. All stand-alone sound systems must have call override from the Intercom/PA system in the case of an emergency.

B. Communications Systems Performance Requirements

- a. Announcement distribution from a central location to zones, individual classrooms, groups or all facility speakers
- b. Broadcast of user defined input (radio signal, compact disc, aux input, etc.) to zones, individual rooms, groups or all facility loudspeakers
- c. Emergency cut-in to all speakers in an emergency situation from a central location
- d. Two-way intercommunication between the central rack, any call-in location or any selected two-way speaker location
- e. Hands free communications by means of a loudspeaker or speakerphone used as a transducer or speaker/microphone combination
- f. Visual and audio monitoring of all intercommunication system activity
- g. Volume and level controls for all centrally located intercommunication system equipment
- h. Tone distribution based off the master clock that can be partitioned into zones
- i. Capability to tie into any auxiliary sound system throughout the facility
- j. High priority call-in from any telephone in an emergency situation
- k. Comply with Regulatory requirements
- l. All work will conform to the National Electric Code and applicable local ordinances

1.3 SUBMITTALS

A. Comply with requirements of Division 0 and Division 1 - Submittals and as modified below.

1. Product Data: Submit manufacturer's product literature, technical specifications and similar information for the following items demonstrating compliance with the specified requirements.

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2. Submit the shop drawings, product data and quality control submittals specified below at the same time as the package
3. Shop Drawings shall include the following items but are not limited to:
 - a. Call Switches
 - b. Speakers
 - c. Admin Handsets
 - d. Cages
 - e. Cards
 - f. Headend Equipment
 - g. Clocks
 - h. Controllers
 - i. Wire types
 - j. Switchers
 - k. System wiring diagrams showing all connections
 - l. Drawings including all equipment locations
 - m. Associated equipment specifications and cut sheets
 - n. Product data including catalog cut sheets, manufacturer's default specifications, user operation guides and a bill of materials
4. Quality Control Submittal
 - a. Submit the name, address and telephone number of the nearest fully equipped service organization.
 - b. Submit a certificate of completion of installation and service training from the system manufacturer.
5. Certificates
 - a. Manufacturer Certification: Submit certification from manufacturer of products to be installed under this contract certifying that Installer is authorized by manufacturer to install specified products.
 - b. Installer Experience Listing: Submit list of at least 5 completed projects as specified below in "Quality Assurance – Qualifications – Installer."
6. Contract Closeout Submittal: Comply with requirements of Division 0, including submission of operating and maintenance instructions as item in "Operation and Maintenance Data" manual described in that Section.

1.4 QUALITY ASSURANCE

- A. All Work shall be installed in a first class, neat and workmanlike manner by skilled Technicians. The quality of the workmanship shall be subject to inspection and approval by authorized CCPS personnel. Any work found to be of inferior quality and/or workmanship shall be replaced and/or reworked until the approval of CCPS is obtained.
- B. Qualifications
 1. Installer
 - a. Must be qualified to cable, terminate, install and program the equipment specified in this Section, certified by manufacturer of products to be installed, and completed at least 5 installations of similar size, nature and complexity as specified for this project.

1.5 WARRANTY

- A. Provide manufacturer's system warranty against electrical or mechanical defects for 2 years from date of final acceptance.
- B. System Assurance: The System Assurance shall cover the failure of the wiring system to support the application which it was designed to support as well as additional application(s) introduced in the future by recognized standards or user forums

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- C. System Certification: Upon successful completion of the installation and subsequent inspection, the Authority shall be provided with a numbered certificate, from the manufacturing company, registering the installation.

1.6 TRAINING

- A. Installing contractor shall provide a minimum of 8 hours of training on system operation and managements as part of their scope of work.
- B. Additional hours shall be provided on a time and materials basis at the request of the owner.
- C. Installing contractor shall provide a video recording on a standard format DVD to the owner which includes training sessions.

1.7 OPERATION AND MAINTENANCE MANUALS

- A. Installing contractor shall provide a minimum of two hardcopy and one electronic copy of all operation and maintenance manuals to the owner at project completion.

1.8 AS-BUILTS

- A. Installing contractor shall provide as-built documentation that includes all system devices, wiring runs, electronics and associated components. As-builts shall show plan view, all devices, device locations and wiring runs. Wiring diagrams and equipment elevations must be included as well.
- B. Drawings shall be supplied in hardcopy and electronic CAD format.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable manufacturers
 - 1. The intercom system shall be manufactured by Carehawk. Substitutions are not allowed. Any other manufacturers will be rejected at the contractor's expense.
 - 2. The clock system shall be Primex system. Substitutions are not allowed. Any other manufacturers will be rejected at the contractor's expense.

2.2 MATERIALS

- A. Product overview
 - 1. Intercom System Equipment
 - a. Supply and install a complete extension of the Public Address, Intercom and Clock system for bell schedule. The system shall be a New Carehawk system.
 - b. The system shall consist of the Central Control Unit with the following features and capabilities
 - c. Provide a separate circuit for each classroom and administrative office so each room can be individually addressed
 - d. Provide connection to corridor, classroom and outside speakers that allow for grouping based on the owner's preference. There must be 32 independent software paging zones that each circuit may be a part of. Each individual point must also have the ability to be paged independent of software zones.
 - e. The ability to connect to VoIP stations in addition to industry standard 25-volt speakers.
 - f. The unit shall have the capacity to expand to 1200 stations and 32 administrative consoles with the addition of plug in modules as required

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- g. The unit shall store all programmable functions in non-volatile EEPROM memory and shall not be lost in the event of a power failure
- h. The unit shall be programmed through a standard Internet web-based browser interface. Any PC connected to the LAN at the facility and having the proper permission levels shall be able to access and program the central control unit.
- i. The unit shall be connected to the LAN at the facility to allow for system access, diagnostics and programming through IP protocols
- j. The unit shall support remote programming via the WAN.
- k. The unit shall support user names and passwords with multiple access levels being programmable by the administrators.
- l. The unit shall allow for daily operations through administrative handsets.
- m. The unit shall allow for priority driven operations with the highest priority calls taking precedence.
- n. The unit shall support normal and emergency calls from a single handset or call switch.
- o. The unit shall support normal calls being switched to all administrative consoles if not answered within a specific period of time.
- 2. Central Controller
 - a. Carehawk CH1000
 - b. Exact model as required
- 3. Remote Audio Card
 - a. Carehawk RAC2
- 4. Equipment Rack
 - a. Hubbell CS1976
- 5. Vented Shelves
 - a. Hubbell
- 6. Rack Mount Kit
 - a. Carehawk RK100
- 7. Rack Base Insulator
 - a. Chatsworth 10605-019
- 8. Grounding Kit
 - a. Hubbell REKEGS
- 9. Blank Panels
 - a. Hubbell
- 10. Switching Security Cards
 - a. Carehawk SS16
 - b. Carehawk SS32
- 11. Accessory Modules
 - a. Carehawk OC16-2
- 12. Network Switch
 - a. Netgear 8 port PoE switch
- 13. Telephone Card
 - a. Carehawk TC2
- 14. VoIP Module
 - a. Carehawk VTM
 - b. Carehawk VG2
- 15. Attenuators
 - a. Carehawk AT1
 - b. Carehawk AT1-2PG
- 16. AM/FM/CD Player
 - a. Denon DN-300Z
 - b. With Antenna Kit
- 17. Power Strip
 - a. APC 10 port
- 18. Admin Display Console
 - a. Carehawk AP1

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- b. The intercom/paging system control console shall be microcomputer based, desk top console, occupying no more than 75 sq. inches of desk space and weighing 2 lbs. It shall be manufactured of high impact, molded plastic with a standard 12 button keypad.
 - c. The console shall provide selected, two-way voice communications and signaling between the console and room stations as well as between other control consoles in the system. The console shall be equipped with a telephone handset with a retractable cord to allow private conversations. A built-in microphone and speaker shall provide for push-to-talk intercom conversations.
 - d. Incoming calls shall be annunciated on a two line 20-character LCD backlit digital display by room number and priority level. The display shall be angle adjustable to ensure the clearest viewing of console information.
 - e. All incoming calls shall be held in memory and displayed sorted by priority and order received. Each of the six levels of priority shall be displayed by a unique priority prefix and call-in tone. The console shall also have facilities for reviewing all incoming calls stored in memory
 - f. The distribution of program material shall be controlled from the administrative control console, room selector switch or DTMF intercom handset. System shall support distribution to any of 31 distribution zones, individual rooms or combination thereof.
 - g. Paging announcements shall be distributed from the control console on an Emergency All Call, All Call, All-Call multiple zone, or individual basis to classroom speakers.
 - h. Any control console in the system shall have the ability to be designated as the "current console" and have the incoming calls from room stations, enunciate at that specific console. This function shall be programmed from the control console and shall allow for simple transfer of the "current console" assignment to any other console in the system.
 - i. The console shall also provide the ability for the operator to place on hold, or clear any incoming calls registered in the system from the console keypad.
 - j. Facilities for activating and controlling remote devices from the control console keypad. The system shall control the operation of external bells, utilizing the internal time clock within the system.
 - k. Capabilities for user programming of alphanumeric architectural room numbers from the control console. The system shall be capable of using 2, 3, 4-digit number, or a letter (A = I) and a 3-digit number. The number for both the classroom speaker and the telephone shall be the same.
 - l. The console shall retain the last room number dialed until another room number is dialed or previous call is cancelled.
 - m. Ability to manually distribute tone signals on an all-call basis from the keypad of the Administrative Control Console cabinet.
 - n. The console shall have the ability to program or change all of the operational characteristics of the Intercom/PA system.
- 19. Volume Controller
 - a. Atlas Sound AT10
 - 20. Call Switch
 - a. Carehawk CS25
 - 21. Call Switch with Speaker
 - a. ICS-3A
 - 22. Desk Paging Mic
 - a. MHL5S
 - 23. Amplifiers
 - a. The power amplifiers shall be manufactured by Carehawk. The system shall be sized at:
 - i. ½ watt per classroom
 - ii. 1 watt per corridor speaker

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- iii. 3.5 watts per interior horn
- iv. 7 watts per exterior horn.
- b. The amplifier load shall not exceed 80% capacity.
- c. The amplifiers shall be capable of producing an audio output of 60, 125 or 250-watts RMS at less than 1% distortion with a balanced output.
- d. They shall be designed to operate on a line voltage of 115 AC. One amplifier shall be provided for each audio channel.
- 24. Administrative Handsets
- 25. Volume Control
 - a. A volume control dial shall be included with each call switch in administrative and office areas. See drawings for locations.
 - b. The volume control dial shall be mounted inline, directly above the call switch.
 - c. The volume control dial shall be the Atlas AT-10 or approved equal.
 - d. The volume control dial shall be compatible with the Carehawk system architecture.
- 26. Speakers
 - a. Lay-in loudspeaker assembly shall be the Quam System 5/25RS lay-in Flush Loudspeaker Assembly with 25v Rotary select Transformer.
 - b. Cut-in speakers shall be Carehawk.
- 27. Horn Loudspeaker
 - a. The horn style loudspeaker shall be a flush mounted Atlas VTF-152UCN or approved equal. Furnish and install as indicated on the plans.
 - b. The horn shall be a double re-entrant type, with a flared bell and an integral compression driver rated for 15 watts of continuous audio power. The frequency response shall be 375 -14,000Hz. Nominal sensitivity shall be such that a sound pressure level of 110 dB at 1000 Hz (on axis) at distance of one meter is produced with an input of one watt. Sound dispersion shall be no less than 100 degrees, regardless of the mounting position.
 - c. The horn shall contain a weatherproof, built-in, 25/70-volt line matching transformer. Power taps shall be at 0.48, 0.94, 1.8, 7.5 or 15 watts for a 25V line and 1, 2, 3.8, 7.5 or 15 watts for a 70 V line. The power taps shall be screwdriver adjustable. Impedance selection shall be 5,000, 2500, 1300, 666, 333, 87, or 45 ohms.
 - d. The unit shall include a die-cast universal mounting bracket, allowing the horn to be positioned both in the vertical and horizontal planes with a single adjustment. The wiring terminals and the screwdriver power tap shall be enclosed by a clear plastic cover for security and weather protection.
 - e. The horn shall be finished in a grey epoxy. Dimensions shall be 9 1/4" deep with a diameter of 8"
 - f. Exterior speakers shall be individual homeruns.
- 28. Remote Interface
 - a. The administrative telephones shall provide a remote interface in the main office area to control the AM/FM and CD player functions of the Intercom System as well as other functions.
- 29. Misc Parts
 - a. 110 Blocks
 - b. Amphenol Cables
- 30. Cable and Jacks
 - a. 18/2 AWG
 - b. 18/4 AWG
 - c. Cat 6 UTP
 - d. XLR Cable
 - e. PA Cable shall be plenum.
 - f. PA Cable shall be yellow.
 - g. PA Jacks shall be yellow.
 - h. PA Cable must be presented to the school district Maintenance and Electrical Department for approval prior to installation.
- 31. Clocks

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- a. Public Space Clocks
 - i. Clocks shall be Primex electric powered with wireless correction. 12" surface, round, 120v powered.
- b. Classroom / Office Clocks
 - i. Clocks shall be Primex battery powered with wireless correction. 12" surface, round, battery powered.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: Examine conditions under which telecommunications cabling and equipment and related components are to be installed in coordination with Installer of materials and components specified in this Section and notify affected Prime Contractors and Design consultant in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected to ensure a safe and timely installation.
 - 1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Design consultant written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.
 - 2. Visit Site to identify and become familiar with existing field conditions and specific requirements of each Site.
 - 3. Verify all dimensions in field and confirm condition of existing hardware to be utilized.
 - 4. Confirm space requirements and physical confines of all work areas to ensure that all materials can be installed in indicated spaces.
 - 5. Confirm all device locations and cable pathways and advise Design consultant in writing of any discrepancies or issues in Design described in Contract Documents.

3.2 PREPARATION

- A. Protection: Provide adequate protection of equipment and hardware before and after installation.
- B. Existing Communications Services: Ensure all telecommunications systems (voice, video and data) remain operational throughout the project.
- C. Identify any additional intercom equipment, devices, and wiring at the site not shown on T-Drawings and interfering with installation of specified equipment.
- D. Remove all accessible portions of abandoned communications cabling per NEC 800.52. Tag all communications cabling not terminated at both ends but retained for future use.

3.3 INSTALLATION

- A. Intercom / Public Address cables shall be their own j-hook with Velcro cable tie and installed separately from other systems. A separate conduit sleeve shall be used when entering rooms.
- B. Provide and install all components necessary to install complete intercom/PA/master clock system, including (but is not limited to) cable, connectors, patch panels, call switches, speakers, etc...
- C. Secure all horizontal cables within ceiling cavities to building structure.

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- D. Loosely bundle all cables and support from structure at unequal intervals from 5 to 6 feet with spring steel fasteners and cable clip rated for use with high performance cables (similar to Caddy Series "CableCat" or approved alternate mounting methods) including placement in cable tray as indicated on Drawings. All mounting clips shall be seismic type as per BOCA.
- E. Do not violate manufacturer's recommended loadings. Leave 30% capacity for future use of pathway.
- F. Verify all horizontal cable run lengths prior to installation. Re-distribute horizontal cabling to maintain distance requirements and maintain pathway route accessibility.
- G. Do not support cables from ceiling grid T-Bars, grid wire supports or bridle rings.
- H. Do not allow cables to touch ceiling grid.
- I. Install cables in EMT conduit in all unfinished, exposed areas as shown in Design consultant roof plans and/or T-Drawings, unless alternate pathways are noted.
- J. Do not secure cables with permanent cable ties. Do not tighten cable bundles in such a way as to cause jacket deformation or damage.
- K. Re-terminate and re-test any cables or pairs of cables failing end-to-end testing requirements. Replace any faulty cables/pairs or termination devices. Remove all defective cables completely from pathways.
- L. Install all exposed cabling in surface raceway by Wiremold, Hubbell or Panduit where in-wall conduit has not been provided. Follow all manufacturers' guidelines requirements regarding bending radius and slack. All bends, offsets and fittings shall be appropriately sized to provide 30% capacity after installation.
- M. Follow manufacturer's guidelines and requirements for all cable termination.
- N. Follow detail drawings to locate equipment racks and cabinets. Where it is necessary to deviate, to obtain 30-inch clearance between equipment, obtain Design consultant's written approval before mounting cabinet/rack.
- O. Ladder-type cable tray shall be affixed 6 inches above all data racks and equipment cabinets and routed to all points of entry into each telecommunications room.
 - 1. Include transition to proper height for penetration into hallway or other wall penetration as indicated on Drawings.
 - 2. Install sufficient 4-inch conduits from telecom rooms into hallway (minimum of 2) with protective insulating bushings, cable spillway or specially designed cable tray sections, with appropriate firestop materials.
- P. Properly terminate all cables at speakers, call switches, administrative consoles and distribution racks. Permanently identify all cables in pull boxes, transition points, and termination points by affixing pre-marked self-adhesive wraps similar to Brady "B-500+ Plastic Cloth Markers."
- Q. Permanently identify all system components following TIA/EIA-606A "Administration Standard for Commercial Telecommunications Infrastructure" with identification format:
 - 1. Identification: Provide permanent identification labels for end devices and associated cabling at each end.

3.4 TESTING

- A. Intercom Testing
 - 1. Intercom and sound system devices shall be tested and verified.
 - 2. Sound levels shall be verified and tapped correctly.

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3. The clock system shall be verified to function and keep correct time.
4. Interaction between the Clock and Intercom System shall be verified.
5. Interaction between the intercom and sound systems shall be verified.

3.5 AS-BUILTS

- A. As-builts shall be provided by the contractor in hardcopy and electronic CAD format prior to project completion and inspection.
- B. As-builts by contractor must include parts lists and wiring diagrams that clearly indicate all equipment, locations, wiring and connections.
- C. Owner's manuals shall be supplied as part of the as-built documentation.

3.6 DEMONSTRATION AND TRAINING

- A. All aspects of the systems must be demonstrated for the owner at the time of training
- B. A minimum of 16 hours of training shall be provided.
- C. Training shall be video and audio recorder for the owner and turned over to the owner at acceptance.

3.7 ACCEPTANCE

- A. Contractors work shall be considered complete after the following conditions have been met:
 1. As-built documentation has been provided and approved.
 2. Cable installation is complete and all cable runs have been tested and documented to be installed according to specifications and drawings.
 3. Equipment installation is complete and all functions have been tested and documented to function as designed and per the manufacturer's recommendations.
 4. All punch list items have been reconciled.
 5. All disturbed ceiling panels, fire stopping materials, covers, etc. have been properly reinstalled.
 6. All materials and trash have been removed from the site.
 7. A 2-Year Installers warranty has been given to a school district Technology representative.
 8. Submit Manufacturers Extended Warranty Application.

END OF SECTION 275000

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ADDITION / RENOVATION

SECTION 28 1000 - INTRUSION DETECTION SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Intrusion Detection cabling
- B. Intrusion Detection sensors
- C. Intrusion Detection end devices
- D. Intrusion Detection headend equipment
- E. Associated power supplies, terminations, equipment, labeling and associated cable performance testing.

1.2 DEFINITIONS

- A. Intrusion Detection system refers to burglar alarm equipment including motion detectors, door contacts, control panels, communication panels, power supplies, expansion modules and associated wiring.

1.3 SYSTEM DESCRIPTION

A. Design Requirements

- 1. Provide labor, materials, equipment, services and operations required for a complete installation an Intrusion Detection System.
 - a. Panels
 - b. Expansion modules
 - c. Keypads
 - d. Annunciators
 - e. Motion Detectors
 - f. Communication Modules
 - g. Power Supplies
 - h. Batteries
- 2. All wiring shall be wired according to manufactures specifications.
 - a. Refer to notes on each drawing to determine exact installation methods.
 - b. Strictly adhere to most current version of TIA/EIA Telecommunications cabling standards.
 - c. Permanently identify and label all cables and termination devices, at distribution rack and workstation in accordance with ANSI/TIA-606 Standard or as agreed by Design consultant and Authority.
 - d. Remove and replace any cables failing to meet end-to-end testing requirements; do not abandon cable in place. All cable shall be terminated at both ends, unless noted in T-Drawings.

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B. Performance Requirements

1. The system shall produce a signal if the system is breached by an unauthorized user.
2. Each sensor shall be individually alarmed.
3. The system shall be capable of being scheduled.
4. The system shall be capable of being controlled from the main panel, keypad locations, central station and PC connected to the LAN.
5. The intrusion detection system will alert and record movement throughout the facility that is both authorized and unauthorized.
6. The systems will be capable of communicating onsite as well as to remote locations.
7. The systems shall be controllable in case of emergency situation.
8. All systems shall operate on dedicated circuits with associated cabling in EMT.
9. Comply with applicable requirements in Local, State and Federal Codes, TIA/EIA Standards, and BICSI methodology.
10. Specified cabling system derived from recommendations in approved telecommunications industry codes, standards and methods, including the following documents:

C. Industry Codes, Standards and Methods shall be observed, including the following:

1. ANSI/TIA-568.0-D: Generic Telecommunications Cabling for Customer Premises.
2. ANSI/TIA-568.1-E: Commercial Building Telecommunications Cabling Standard
3. ANSI/TIA-568-2-D: Balanced Twisted Pair Cabling and Components Standard
4. ANSI/TIA-568.3-D: Optical Fiber Cabling Components Standard
5. ANSI/TIA-569-E: Telecommunications Pathways and Spaces
6. ANSI/TIA-606-C: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
7. ANSI/TIA-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications
8. ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Cabling Standard
9. ANSI/TIA-4966: Telecommunications Infrastructure Standards for Educational Facilities
10. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition
11. National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)

1.4 SUBMITTALS

- A. Comply with requirements of Division 0 and Division 1 - Submittals and as modified below.

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- B. Product Data: Submit manufacturer's product literature, technical specifications and similar information for the following items demonstrating compliance with the specified requirements.
1. Motion Detectors, Door Contacts, Keypads
 2. Control Panels and Communications Modules
 3. Power supplies
 4. Copper cable and termination devices.
 5. Inner duct and accessories.
 6. Wiring diagrams.
- C. Samples: Provide samples of assemblies and connections as described below, prior to installation, for approval by designer.
1. Intrusion Detection cables and connections – Submit samples of cables and terminations to be provided including following components and characteristics:
 - a. Provide all components in colors selected by Design consultant.
- D. Quality Control Submittal
1. Test Reports: Submit complete sample test data and reports with exact labels used on cables termination fields.
 2. Certificates
 - a. Manufacturer Certification: Submit certification from manufacturer of products to be installed under this contract certifying that Installer is authorized by manufacturer to install specified products.
 - b. Installer Experience Listing: Submit list of at least 5 completed projects as specified below in "Quality Assurance – Qualifications – Installer."
- E. Contract Closeout Submittal: Comply with requirements of Division 0, including submission of operating and maintenance instructions as item in "Operation and Maintenance Data" manual described in that Section.

1.5 QUALITY ASSURANCE

- A. All Work shall be installed in a first class, neat and workmanlike manner by skilled Technicians. The quality of the workmanship shall be subject to inspection and approval by authorized school district personnel. Any work found to be of inferior quality and/or workmanship shall be replaced and/or reworked until the approval of school district personnel is obtained.
- B. Qualifications
1. Installer
 - a. Qualified to cable, terminate, program and test Intrusion Detection systems, and associated power wiring specified in this Section and other Division 17000 series specifications, certified by manufacturer of products to be installed, and completed at least 5 installations of similar size, nature and complexity as specified for this project.

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- C. Conditions for Consideration of "Or Equal" Products: Where products are specified by name and accompanied by the term "or equal", the proposed "or equal" product will be considered when the following conditions are satisfied. If all the following conditions are not satisfied, Design Consultant will return requests without action, except to record noncompliance with these requirements:
1. Proposed product does not require extensive revisions to the Contract Documents.
 2. With the exception of the product name or number and manufacturer's name, proposed product conforms with requirements indicated on the Drawings and in the Specifications in every respect and will produce indicated results.
 3. Proposed product is fully documented and properly submitted.
 4. Proposed product has received necessary approvals of authorities having jurisdiction.
 5. Proposed product is compatible with AND has been coordinated with other portions of the Work.
 6. Proposed product provides specified warranty.
 7. If proposed product involves more than one contractor, proposed product has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.
 8. Submission is accompanied with detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
 9. Submission is accompanied with a list of similar installations for completed projects with project names and addresses and names and addresses of design consultants and authorities, if requested.
 10. Submission is accompanied with proposed product's Manufacturer signed written statement on Manufacturer's letterhead, certifying that manufacturer complies with requirements in the Contract Documents.

1.6 WARRANTY

- A. Installer's Warranty: Provide manufacturer's system warranty against electrical or mechanical defects for 2 years from date of final acceptance.
- B. Manufacturer warranty coverage for cable systems associated with the Intrusion Detection System and associated Access Control System

1.7 TRAINING

- A. Installing contractor shall provide a minimum of 8 hours of training on system operation and managements as part of their scope of work.
 1. Additional hours shall be provided on a time and materials basis at the request of the owner.
- B. Installing contractor shall provide a video recording on a standard format DVD to the owner which includes training sessions.

1.8 OPERATION AND MAINTENANCE MANUALS

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- A. Installing contractor shall provide a minimum of two hardcopy and one electronic copy of all operation and maintenance manuals to the owner at project completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. The Intrusion Detection System shall be a Bosch system, no substitutions will be allowed.
(Current district equipment)

2.2 MATERIALS

- A. Basis of Design
1. Bosch B5912G (Existing in Security Room)

2.3 INTRUSION DETECTION

- A. Control Panel
1. Bosch
 - a. Up to 599 points
 - b. Support for 32 Keypads
 - c. Up to 8 partitions
 2. Plug-in Phone Line
 - a. Bosch B430
 3. Cellular Communicator
 - a. Bosch B440
 4. Ethernet Module
 - a. Bosch B426
 5. Keypads
 - a. Bosch B920 with LCD Display
 6. Motion Detectors
 - a. Bosch Commercial TriTech Wide Angle
 - b. Bosch Commercial TriTech Medium Range
 - c. Bosch Commercial TriTech Long Range
 7. Expansion Modules
 - a. Bosch Expander
 8. Power Supplies
 - a. Located in MDF and IDF Rooms as required.
 9. Cable

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- a. Two Conductor 18 AWG min
 - b. Four Conductor 18 AWG min
10. Battery Backup
- a. Provide properly sized backup battery power supply for full system operation.
- B. Cable/Wiring
- 1. ALL CABLE/WIRING SHALL BE RUN IN WHITE, EMT CONDUIT. Provide Allied True Color products, or equal. All junction boxes are to be painted white to match conduit. All wiring shall be concealed. No surface metal raceway shall be used unless approved by owner, and if approved, shall be painted to match adjacent wall color.
 - a. General: 18-AWG, 4-wire, unshielded. Provide two (2) cable loops for connection of all devices. Alternate connection of devices between cable loops such that every other device in series is connected to one cable and the other cable is connected to every other device remaining. Cable shall be West Penn Model 25244, or approved equal.
 - 2. Surge Protection: Provide transient surge protection devices on the power feeds for all major components of equipment. This shall include equipment with electronic components such as the control panel. Surge protection devices shall be UL listed, equal to Transtector or Isobar. The devices shall have a 5 nanosecond or less response time for clipping excessive voltage. The surge protection devices shall consist of solid state circuitry, will automatically reset after an operation with no degradation in protective capability and have an indicated light to indicate when the unit is non-operational. Devices shall be direct plug-in type, plug strip type, or hard-wired connection type as applicable.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: Examine conditions under which Intrusion Detection cabling and equipment and related components are to be installed in coordination with Installer of materials and components specified in this Section and notify affected Prime Contractors and Design consultant in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected to ensure a safe and timely installation.
- 1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Design consultant written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.
 - 2. Visit Site to identify and become familiar with existing field conditions and specific requirements of each Site.
 - 3. Verify all dimensions in field and confirm condition of existing hardware to be utilized.
 - 4. Confirm space requirements and physical confines of all work areas to ensure that all materials can be installed in indicated spaces.
 - 5. Confirm all outlet locations and cable pathways and advise Design consultant in writing of any discrepancies or issues in Design described in Contract Documents.

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3.2 PREPARATION

- A. Protection: Provide adequate protection of equipment and hardware before and after installation.
- B. Existing Intrusion Detection Equipment: Ensure all systems remain operational throughout the project.
 1. Identify any circuits and/or wiring at the site not shown on T-Drawings and interfering with installation of specified Equipment.
 2. Remove all accessible portions of abandoned communications cabling per NEC 800.52. Tag all communications cabling not terminated at both ends but retained for future use.

3.3 INSTALLATION

- A. Provide and install all components necessary to install a complete Intrusion Detection System, including (but is not limited to) connectors, sensors, panels, power supplies, terminators, etc...
 1. Cable runs shall be per manufacturer's recommendations in all cases. Any deviation will result in system rejection.
 2. Secure all horizontal cables within ceiling cavities to building structure.
 3. Loosely bundle all cables and support from structure at unequal intervals from 5 to 6 feet with spring steel fasteners and cable clip rated for use with high performance cables where cable tray or other support structure has not been provided as indicated on Drawings. All mounting clips shall be seismic type as per BOCA.
 4. Do not violate manufacturer's recommended loadings. Leave 30% capacity for future use of pathway.
 5. Do not support cables from ceiling grid T-Bars, grid wire supports or bridle rings. Do not allow cables to touch ceiling grid.
 6. Install cables in EMT conduit in all unfinished, exposed areas as shown in Design consultant and Architectural roof plans and/or T-Drawings, unless alternate pathways are noted.
 7. Do not secure cables with permanent cable ties. Do not tighten cable bundles in such a way as to cause jacket deformation or damage.
 8. Place cables in compliance with ANSITIA 568.C standards and BICSI recommended methods.
 9. Tight 90-degree bends are unacceptable and use of plastic "cinch-type" tie-wraps are not permitted, in order to prevent damage to cable jacket and compromise the cable's electrical or optical characteristics.
 10. Cable bundles shall be neatly routed with a service loop to provide 10 feet of slack at the cross-connect end and as noted in the T-drawings. Cable bundles shall be secured using only black Velcro cable wraps.
- B. Install all exposed cabling in surface raceway by Wiremold, Hubbell or Panduit where in-wall conduit has not been provided. Follow all manufacturers' guidelines requirements regarding bending radius and slack. All bends, offsets and fittings shall be appropriately sized to provide 30% capacity after installation.

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- C. Install all cable in accordance with National, state and local codes and ANSI/TIA Standards, and BICSI methods.
1. Follow manufacturer's guidelines and requirements for all cable termination.
 2. Identification: Provide permanent identification labels for patch panels, access panels and entrance facilities.
 3. The security alarm system shall have its devices labeled so they can be identified by its zone number visible from floor.

3.4 TESTING

A. Intrusion Detection System

1. Upon completion of work, all parts of Intrusion Detection System installation shall be tested by the installing Contractor and demonstrated free of any defects. Preliminary testing will be permitted but shall not be accepted in lieu of obtaining final test results. Final test results shall be accomplished by the use of proper test equipment for the system being tested.
2. Each device shall be demonstrated to individually alarm and pin point the exact triggered sensor. Any system failing this requirement will be wholly rejected at the contractor's expense.
3. Re-terminate and re-test any cables or pairs of cables failing end-to-end testing requirements. Replace any faulty cables/pairs or termination devices. Remove all defective cables completely from pathways.

3.5 AS-BUILT DRAWINGS

A. Shall be provided in electronic and hard copy format.

1. A graphic map for the entire intrusion system shall installed above main intrusion panel with zone #s, power supplies, keypads and sensor locations, door contacts and monitor modules. 14" x 14" minimum.
2. 3 copies of electronic (CAD) drawings shall be distributed on appropriate media: 1 to construction management, 1 to designers and 1 to school district personnel.
3. 3 hard copies of CAD drawings shall be plotted on full size sheets and test results of every installed cable have been given to the construction management for appropriate distribution.

3.6 ACCEPTANCE

A. Contractors work shall be considered complete after the following conditions have been met:

1. Contractor to monitor intrusion for 30 days prior to turning over to CCPS.
2. Cable installation is complete and all cable runs have been tested and documented to be installed according to specifications and drawings. Use form at the bottom of this specification for zone descriptions and delineation.
3. A school district Security and Technology representative has successfully tested the "LIVE" system.
4. All punch list items have been reconciled.

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5. All disturbed ceiling panels, covers, etc. have been properly reinstalled.
6. All materials and trash have been removed from the site.
7. A 2-Year Installers warranty has been given to a school district Security and Technology representative.
8. Submit Manufacturers Extended Warranty Application.

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Contact ID

ACCOUNT# Subscriber Name _____

CHOOSE ONE:

- ADDENDUM** TO A NEW SUBSCRIBER MONITORING AGREEMENT.

CHANGE TO DATA ON AN EXISTING SUBSCRIBER ACCOUNT.

NOTE: UNLESS OTHERWISE INDICATED, THE DEFAULT CALLBACK OPTION FOR RESTORE IS LOG ONLY; TROUBLE IS DEALER ONLY.

PLEASE INDICATE CALLBACK OPTION. EXCLUSION OF THIS INFORMATION MAY DELAY THE PROCESSING OF A SUBSCRIBER MONITORING AGREEMENT. IF YOU HAVE ANY QUESTIONS, PLEASE CONTACT YOUR REPRESENTATIVE.

PANEL: BOSCH NAPCO FBI APEX OTHER (SPECIFY) _____

PARTITIONED?: NO YES (DEFINE BELOW)

1	5
2	6
3	7
4	8

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END OF SECTION 281000

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SECTION 28 1300 - ACCESS CONTROL SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Access Control Cabling
- B. Access Control Door Controllers
- C. Access Control Card Readers
- D. Access Control materials, terminations, equipment, labeling and associated cable performance testing.
- E. Video Intercom and Door Release System (AIPhone).
- F. Lock Release Buzzers

1.2 DEFINITIONS

- A. Access Control system refers to equipment including door controllers, card readers, control panels, power supplies and associated cabling for a complete and operational system.
- B. Refer to section 28 10 00 for associated and integrated Intrusion Detection Equipment.

1.3 SYSTEM DESCRIPTION

A. Design Requirements

- 1. Provide labor, materials, equipment, services and operations required for a complete installation of an Access Control System.
 - a. Base panel
 - b. Door Controllers
 - c. Card Readers
 - d. Annunciators
 - e. Communication Modules
 - f. Power Supplies
 - g. Lock Release devices
- 2. All wiring shall be wired according to manufacturer's specifications.
 - a. Refer to notes on each drawing to determine exact installation methods.
 - b. Strictly adhere to most current version of ANSI/TIA Telecommunications cabling standards.
 - c. Permanently identify and label all cables and termination devices in accordance with ANSI/TIA-606 Standard or as agreed by Design consultant and Authority.
 - d. Remove and replace any cables failing to meet end-to-end testing requirements; do not abandon cable in place. All cable shall be terminated at both ends, unless noted in T-Drawings.

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B. Performance Requirements

1. All doors shall be initially be programmed in lock mode.
2. Provide "emergency" lockdown function to energize all electric locks throughout the project using the system keypad.
3. The system shall produce a signal (both visual and audible) if the system is breached by an unauthorized user.
4. The Access Control system will allow, prevent and record entry to the facility.
5. The systems will be capable of communicating onsite as well as to remote locations.
6. The system shall be programmable onsite and offsite.
7. The system shall be programmable from a PC to allow or deny access to card holders based on time of day, specific door privileges and access levels.
8. The systems shall be controllable in case of emergency situation.
9. All systems shall operate on dedicated circuits with associated cabling in EMT.
10. Comply with applicable requirements in Local, State and Federal Codes, ANSI/TIA Standards, and BICSI methodology.
11. Specified cabling system derived from recommendations in approved telecommunications industry codes, standards and methods, including the following documents:

C. Industry Codes, Standards and Methods shall be observed, including the following:

1. ANSI/TIA-568.0-D: Generic Telecommunications Cabling for Customer Premises.
2. ANSI/TIA-568.1-E: Commercial Building Telecommunications Cabling Standard
3. ANSI/TIA-568-2-D: Balanced Twisted Pair Cabling and Components Standard
4. ANSI/TIA-568.3-D: Optical Fiber Cabling Components Standard
5. ANSI/TIA-569-E: Telecommunications Pathways and Spaces
6. ANSI/TIA-606-C: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
7. ANSI/TIA-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications
8. ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Cabling Standard
9. ANSI/TIA-4966: Telecommunications Infrastructure Standards for Educational Facilities
10. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition
11. National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)

1.4 SUBMITTALS

- A. Comply with requirements of Division 0 and Division 1 - Submittals and as modified below.

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- B. Product Data: Submit manufacturer's product literature, technical specifications and similar information for the following items demonstrating compliance with the specified requirements.
1. Card Readers
 2. Access Cards
 3. Door Controllers
 4. Headend Control Panels and Communications Modules
 5. Power supplies
 6. Copper cable and termination devices.
 7. Inner duct and accessories.
 8. Wiring diagrams.
- C. Shop Drawings
1. The System contractor shall provide a one-line riser diagram indicating equipment locations, mounting type, cable type and length, cable route and conduit size and connections of system proposed.
 2. Furnish complete operating instructions, including schematic and wiring diagrams of the system, engineering data sheets on each component and complete servicing data including part numbers of the various components
 3. UPS sizing calculations
 4. Locate all components on shop drawings and as-builts
- D. Equipment Cut Sheets
1. All equipment must be clearly labeled with exact quantities and parts specified for use on the job.
 2. Any equipment not clearly called out in product data submittals will be rejected without question and must be resubmitted at no cost to the owner.
- E. Quality Control Submittal
1. Test Reports: Submit complete sample test data and reports with exact labels used on cables termination fields.
 2. Certificates
 - a. Manufacturer Certification: Submit certification from manufacturer of products to be installed under this contract certifying that Installer is authorized by manufacturer to install specified products.
 - b. Installer Experience Listing: Submit list of at least 5 completed projects as specified below in "Quality Assurance – Qualifications – Installer."
- F. Contract Closeout Submittal: Comply with requirements of Division 0, including submission of operating and maintenance instructions as item in "Operation and Maintenance Data" manual described in that Section.

1.5 QUALITY ASSURANCE

- A. All Work shall be installed in a first class, neat and workmanlike manner by skilled Technicians. The quality of the workmanship shall be subject to inspection and approval by authorized OWNER personnel. Any work found to be of inferior quality and/or workmanship shall be replaced and/or reworked until the approval of OWNER is obtained.

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B. Qualifications

1. Installer

- a. Qualified to cable, terminate, program and test Access Control systems, and associated power wiring specified in this Section and other Division 17000 series specifications, certified by manufacturer of products to be installed, and completed at least 5 installations of similar size, nature and complexity as specified for this project.

C. Conditions for Consideration of "Or Equal" Products: Where products are specified by name and accompanied by the term "or equal", the proposed "or equal" product will be considered when the following conditions are satisfied. If all the following conditions are not satisfied, Design Consultant will return requests without action, except to record noncompliance with these requirements:

1. Proposed product does not require extensive revisions to the Contract Documents.
2. With the exception of the product name or number and manufacturer's name, proposed product conforms with requirements indicated on the Drawings and in the Specifications in every respect and will produce indicated results.
3. Proposed product is fully documented and properly submitted.
4. Proposed product has received necessary approvals of authorities having jurisdiction.
5. Proposed product is compatible with AND has been coordinated with other portions of the Work.
6. Proposed product provides specified warranty.
7. If proposed product involves more than one contractor, proposed product has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.
8. Submission is accompanied with detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
9. Submission is accompanied with a list of similar installations for completed projects with project names and addresses and names and addresses of design consultants and authorities, if requested.
10. Submission is accompanied with proposed product's Manufacturer signed written statement on Manufacturer's letterhead, certifying that manufacturer complies with requirements in the Contract Documents.

1.6 WARRANTY

- A. Installer's Warranty: Provide manufacturer's system warranty against electrical or mechanical defects for 2 years from date of final acceptance.
- B. Manufacturer warranty coverage for cable systems associated with the Access Control System.

1.7 TRAINING

- A. Installing contractor shall provide a minimum of 8 hours of training on system operation and managements as part of their scope of work.

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1. Additional hours shall be provided on a time and materials basis at the request of the owner.
- B. Installing contractor shall provide a video recording on a standard format DVD to the owner which includes training sessions.

1.8 OPERATION AND MAINTENANCE MANUALS

- A. Installing contractor shall provide a minimum of two hardcopy and one electronic copy of all operation and maintenance manuals to the owner at project completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable manufacturers
 1. The Access Control System shall be a Honeywell System by EASI Controls. No substitutions will be allowed.
 2. The single door entry system shall be an APHONE System, no substitutions will be allowed.
 3. Wireless strike release for AI Phone doors shall be Liner Access, no substitutions will be allowed unless approved by the school system and system engineer.

2.2 MATERIALS

- A. Main Panel
 1. Honeywell SEC-H-201
- B. Door Controller
 1. General Electric WIU-4 Entry-Control Controller
 2. Expansion Modules
 - a. Honeywell SEC-H-R2R Two-Reader Module
 - b. Provide as part of an integrated system with the Intrusion Detection System.
 - c. Provide at each door with access control as shown on the T series drawings.
 - d. Unit shall interface with the card reader at the door and communicate with the main control panel
 3. Access Card Readers– HID iClass SE R40
 - a. Provide at each door with a card reader as shown on the T series drawings.
 4. Power Supplies
 - a. Per Manufacturer recommendations
 - b. Locate in dedicated telecommunications spaces or directly above the door being served.
 - c. Battery Backup shall supply a minimum of 4 hours of runtime.
 5. Cabling

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- a. Per Manufacturer recommendations
 - b. Cabling shall be adequately sized for the installed distance to devices.
 - c. ALL CABLING SHALL BE RUN IN CONDUIT.
- C. AIPhone Door Entry System (No Substitutes)
- 1. Aiphone JP Series Flush Exterior Station
 - 2. Aiphone JP-4MED Interior Station with 7" Touch Screen
 - 3. Aiphone RY-IP44 IP Relay Adaptor
 - 4. Aiphone IS-PU-UL Power Supply
 - 5. Electric Door Hardware (See door hardware section)
 - 6. Associated cables, connectors and mounting equipment.
 - 7. See drawings for pathway locations and sizes.
 - 8. All pathways shall have pull strings left intact.
- D. Lock Release Buzzers
- 1. Honeywell 269R Hold-up Switch
 - a. Or Similar
 - 2. Multiconductor wiring per manufacturer specifications.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: Examine conditions under which Access Control cabling and equipment and related components are to be installed in coordination with Installer of materials and components specified in this Section and notify affected Prime Contractors and Design consultant in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected to ensure a safe and timely installation.
- 1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Design consultant written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.
 - 2. Visit Site to identify and become familiar with existing field conditions and specific requirements of each Site.
 - 3. Verify all dimensions in field and confirm condition of existing hardware to be utilized.
 - 4. Confirm space requirements and physical confines of all work areas to ensure that all materials can be installed in indicated spaces.
 - 5. Confirm all locations and cable pathways and advise Design consultant in writing of any discrepancies or issues in Design described in Contract Documents.

3.2 PREPARATION

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- A. Protection: Provide adequate protection of equipment and hardware before and after installation.
- B. Existing Access Control Equipment: Ensure all systems remain operational throughout the project.
 - 1. Identify any circuits and/or wiring at the site not shown on T-Drawings and interfering with installation of specified Equipment.
 - 2. Remove all accessible portions of abandoned communications cabling per NEC 800.52. Tag all communications cabling not terminated at both ends but retained for future use.

3.3 INSTALLATION

- A. Provide and install all components necessary to install a complete Access Control System, including (but is not limited to) connectors, card readers, door controllers, power supplies, terminators, etc...
 - 1. Cable runs shall be per manufacturer's recommendations in all cases. Any deviation will result in system rejection.
 - 2. Secure all horizontal cables within ceiling cavities to building structure.
 - 3. Loosely bundle all cables and support from structure at unequal intervals from 5 to 6 feet with spring steel fasteners and cable clip rated for use with high performance cables where cable tray or other support structure has not been provided as indicated on Drawings. All mounting clips shall be seismic type as per BOCA.
 - 4. Do not violate manufacturer's recommended loadings. Leave 30% capacity for future use of pathway.
 - 5. Do not support cables from ceiling grid T-Bars, grid wire supports or bridle rings. Do not allow cables to touch ceiling grid.
 - 6. Install cables in EMT conduit in all unfinished, exposed areas as shown in Design consultant and Architectural roof plans and/or T-Drawings, unless alternate pathways are noted.
 - 7. Do not secure cables with permanent cable ties. Do not tighten cable bundles in such a way as to cause jacket deformation or damage.
 - 8. Place cables in compliance with ANSITIA-568.C standards and BICSI recommended methods.
 - 9. Tight 90-degree bends are unacceptable, and use of plastic "cinch-type" tie-wraps are not permitted, in order to prevent damage to cable jacket and compromise the cable's electrical or optical characteristics.
 - 10. Cable bundles shall be neatly routed with a service loop to provide 10 feet of slack at the cross-connect end and as noted in the T-drawings. Cable bundles shall be secured using only black Velcro cable wraps.
- B. All cables necessary for card access and AIPHONE operation are required as part of this scope of work.
 - 1. Coordination must occur between this contractor, the door hardware contractor and the electrical contractor to ensure doors, card access and AIPHONES are fully operational.

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- C. Install all exposed cabling in surface raceway by Wiremold, Hubbell or Panduit where in-wall conduit has not been provided. Follow all manufacturers' guidelines requirements regarding bending radius and slack. All bends, offsets and fittings shall be appropriately sized to provide 30% capacity after installation.
- D. Install all cable in accordance with National, state and local codes and ANSI/TIA Standards, and BICSI methods.
 - 1. Follow manufacturer's guidelines and requirements for all cable termination.

3.4 PROGRAMMING AND PRINTING

- A. Access Control and AIPHONE programming shall be included as part of this scope of work.
 - 1. The Access Control System shall be fully operational and all programming included.
 - 2. The owner shall provide a list of users, access cards, access levels, time schedules and credential levels for all credential holders. This must be coordinated with the owner at the time of programming.
 - 3. AIPHONES shall be fully programmed and operational including all ring schedules.
 - 4. Access Control and AIPHONE systems must be integrated with other electric door hardware devices and equipment including ADA operators, hold opens, electric locks and door contacts.
 - 5. All access credential shall be printed with the proper owner information as part of this scope of work.
 - 6. Program 100 cards as part of this scope of work.

3.5 TESTING

- A. Access Control and AIPHONE System
 - 1. Upon completion of work, all parts of Access Control and AIPHONE Systems installation shall be tested by the installing Contractor and demonstrated free of any defects. Preliminary testing will be permitted but shall not be accepted in lieu of obtaining final test results. Final test results shall be accomplished by the use of proper test equipment for the system being tested.
 - 2. Re-terminate and re-test any cables or pairs of cables failing end-to-end testing requirements. Replace any faulty cables/pairs or termination devices. Remove all defective cables completely from pathways.

3.6 DEMONSTRATION AND TRAINING

- A. Provide a minimum of four (4) hours of factory authorized training to Facilities personnel (between 4 and 10 individuals). Upon completion of training, individuals shall receive a factory certificate of completion for installation-maintenance-service seminar, and a copy of all technical service manuals and associated software. Cost for transportation and lodging for any off-site training beyond fifty miles from project site shall be reimbursed to each individual.

3.7 AS-BUILT DRAWINGS

- A. Shall be provided in electronic and hard copy format.

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1. 3 copies of electronic (AutoCAD 2015) drawings shall be distributed on appropriate media: 1 to construction management, 1 to designers and 1 to OWNER.
2. 3 hard copies of (AutoCAD 2015) drawings shall be plotted on full size sheets and test results of every installed cable have been given to the construction management for appropriate distribution.
3. 11 X 17" Card Access system control panel and card access system riser.

3.8 ACCEPTANCE

- A. Contractors work shall be considered complete after the following conditions have been met:
 1. Cable installation is complete and all cable runs have been tested and documented to be installed according to specifications and drawings.
 2. An OWNER Technology/Security representative has successfully tested the "LIVE" system.
 3. All system programming has been verified and demonstrated to the owner.
 4. All punch list items have been reconciled.
 5. All disturbed ceiling panels, covers, etc. have been properly reinstalled.
 6. All materials and trash have been removed from the site.
 7. A 2-Year Installers warranty has been given to an OWNER Technology representative.
 8. Submit Manufacturers Extended Warranty Application.

END OF SECTION 281300

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ADDITION / RENOVATION

SECTION 28 23 00 - VIDEO SURVEILLANCE SYSTEM

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. The general provisions of the Contract, including General and Supplementary Conditions and General Requirements, apply to the work specified in this Section.

1.2 SUMMARY

- A. Section includes a Video Surveillance System (CCTV) System as indicated on the TY series drawings.
1. Video surveillance cabling
 2. Video surveillance hardware, cameras and components
 3. Video Surveillance NVRs
 4. Video Surveillance power supplies and ups equipment
 5. Video surveillance software and applications

1.3 REFERENCES

- A. The complete installation, including additions and modifications, shall be in accordance with:
1. National Electrical Code Article 800
 2. Minimum standards of ANSI/TIA
 3. Security Industry Association (SIA) guidelines

1.4 SYSTEM DESCRIPTION

A. Design Requirements

1. Provide a complete NVR base CCTV system
 - a) The CCTV system shall have recorders connected to the local area network.
 - b) NVR and power supply equipment shall be located in telecommunications spaces.
 - c) The CCTV system shall be connected to UPS equipment and on facility emergency backup power.
 - d) CCD cameras with indicated enclosure, mounts and domes.
 - e) NVR network viewing of live & recorded video
 - f) Lenses, automatic iris lenses and lens controls
 - g) Rack type cabinets, cabling and miscellaneous materials as required and specified herein, and in accordance with the applicable codes
2. The CCTV system shall be designed to accommodate a 90+ camera system. Parts listed within this specification shall remain the same for the system; however, quantities of parts may change to correspond to the number of cameras. Refer to contract drawings for exact quantities of devices and locations.

B. Performance Requirements

1. The system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
2. The CCTV System shall have the capability of live recording, viewing and playback simultaneously.
3. Live video searching.
4. Time and Data stamp
5. PTZ control from a keyboard or via remote software.

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6. Video archiving
 7. Day/Night recording capabilities
 8. H.264/h.265 compression
 9. Multiple frame rate recording from 1fps to 30 fps.
 10. Access to the system via IP communications on the district LAN and WAN.
 11. Multiple NVR units function as virtual unit.
 12. Megapixel camera resolutions.
- C. Code Requirements
1. Comply with applicable requirements in Local, State and Federal Codes, ANSI/TIA Standards, and BICSI methodology.
 2. Specified cabling system derived from recommendations in approved telecommunications industry codes, standards and methods, including the following documents:
 - a) Security Industry Association Methods and Standards
 - b) ANSI/TIA-568.0-D: Generic Telecommunications Cabling for Customer Premises.
 - c) ANSI/TIA-568.1-E: Commercial Building Telecommunications Cabling Standard
 - d) ANSI/TIA-568-2-D: Balanced Twisted Pair Cabling and Components Standard
 - e) ANSI/TIA-568.3-D: Optical Fiber Cabling Components Standard
 - f) ANSI/TIA-569-E: Telecommunications Pathways and Spaces
 - g) ANSI/TIA-606-C: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
 - h) ANSI/TIA-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications
 - i) ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Cabling Standard
 - j) ANSI/TIA-4966: Telecommunications Infrastructure Standards for Educational Facilities
 - k) BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition
 - l) National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)

1.5 SUBMITTALS

- A. Shop Drawings
1. The CCTV System contractor shall provide a one-line riser diagram indicating camera location, mounting type, cable type and length, cable route and conduit size and connections of system proposed.
 2. Furnish complete operating instructions, including schematic and wiring diagrams of the system, engineering data sheets on each component and complete servicing data including part numbers of the various components
 3. UPS sizing calculations
 4. Locate all components on shop drawings and as-builts
- B. Equipment Cut Sheets
1. All equipment must be clearly labeled with exact quantities and parts specified for use on the job. Any equipment not clearly called out in product data submittals will be rejected without question and must be resubmitted at no cost to the owner.
- C. As-Built Drawings
1. As-Built drawings shall be submitted in AutoCad 2015 or later electronic format and duplicate hardcopy format when the system has been completely installed. Drawings shall indicate all wiring and connections.
 2. As-Builts shall include O&M manuals, cut sheets and manuals.
 3. Provide 3 copies electronically and in hardcopy

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1.6 QUALITY ASSURANCE

- A. Source Quality Control - Materials and equipment shall be new, unused and UL listed.
- B. The system and components shall be supplied by one manufacturer of established reputation and experience who shall have produced similar apparatus for a period of five (5) years and who shall be able to refer to similar installations rendering satisfactory service.
- C. The manufacturer's authorized distributor and installation contractor for the specified systems, hereinafter known as the "CCTV System Trade", shall install the CCTV Systems.
- D. The installation shall include wiring, components, connections, adjustment, testing and certification. The Electrical Trade shall provide conduit, junction boxes and pull boxes as indicated and required by the CCTV System manufacturer's drawings or Trade instructions. The CCTV Trade shall furnish any special boxes, cabinets, enclosures and similar items to the Electrical Trade for installation by the Electrical Trade in accordance with the manufacturer's drawings, Trade instructions, and as indicated on Drawings.
- E. The CCTV System Trade shall furnish a list of similar or equal installations and demonstrate five (5) years certifiable experience in this type of work.

1.7 WARRANTY

- A. The CCTV System manufacturer and Trade shall warrant the CCTV Systems for a minimum of two (2) years from date of acceptance by Owner against defective parts and/or workmanship and shall provide parts and labor to fulfill this warranty at no cost to Owner
- B. Qualified service and parts shall be available to call on within a 150-mile basis
- C. The CCTV System Trade shall include in his quotation the cost of three (3) inspections of the system during the two (2) year subsequent to the installation. The Trade installing this equipment shall be prepared to offer the Owner a service contract after the guarantee period has ended. On-the-premises service furnished at other than normal working hours shall also be available and shall be charged at current labor rates. Sub-letting of this service shall disqualify the bidder.

1.8 COMMISSIONING

- A. Final tests and inspection shall be held in the presence of the owner and to their satisfaction. The CCTV System Trade shall supply personnel and required auxiliary equipment for this test without additional cost.
- B. The completed CCTV Systems shall be tested to insure it is operating properly. Acceptance of the systems shall also require a demonstration of the stability of the systems. This shall be adequately demonstrated if the system operates for a ninety (90) day test period without any problems. Should a problem occur, the System Trade shall readjust or replace the defective components and begin another ninety (90) day test period. This test shall not start until the Owner has obtained beneficial use of the building under tests.
- C. If the requirements provided in the paragraph above are not completed within one (1) year after beginning the tests described therein, the CCTV System Trade shall replace either or both systems with another acceptable manufacturer and the process repeated until acceptance of the equipment by the Architect/Engineer.

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PART 2 - PRODUCTS

2.1 EQUIPMENT

A. General

1. All materials, equipment, accessories, devices and other facilities for the CCTV Systems shall be new, best suited for its intended use and shall conform to applicable and recognized standards for their use. All equipment shall be the standard cataloged products of the manufacturers shown.

B. Manufacturers: Subject to compliance with requirements, provide only product listed:

1. HPE, Hewlett Packard Enterprise

C. External storage or internal 16-TB hard disk drive. HPE DL380 G9

1. Provide necessary recording capacity in 16 GB multiples.
2. Video and audio recording over TCP/IP network.
3. Video recording of MPEG-2 and MPEG-4 streams.
4. Video recording up to 48 Mbps for internal storage and up to 100 Mbps for external storage.
5. Duplex Operation: Simultaneous recording and playback.
6. Continuous and alarm-based recording.
7. Full-Featured Search Capabilities: Search based on camera, time, or date.
8. Automatic data replenishment to ensure recording even if network is down.
9. Digital certification by watermarking.
10. Internal RAID storage or non-RAID storage of up to 16 TB.
11. Capable of adding external RAID storage up to 16 TB for models with no internal storage.
12. Full integration with LAN, Intranet, or Internet through standard Web browser or video management software.
13. Integrated Web server FTP server functionality.
14. Support quantity of devices indicated on plans.
15. Rack mountable

D. Switching Equipment:

1. By owner, coordinate with exact switching equipment

E. Video Cameras: (No substitutions)

1. Interior Camera:
 - a) Axis P3245-V
2. Exterior Fixed Camera:
 - a) Axis P3245-LVE
3. All cameras shall be provided with (at the contractor's expense) a dedicated license per camera, to be compatible with OnSSI version 5 Enterprise software (owner provided software).

F. Cabling:

1. Acceptable manufacturers: Commscope, Belden, Berk-Tek, General Cable Technologies, Mohawk/CDT, and West Penn Wire/CDT.
2. NFPA 70, Type CMP plenum rated per manufacturer's recommendations.
3. Unshielded twisted pair (UTP) camera cabling: Category 6, plenum rated.
4. Cable shall be yellow.

G. Patch Panels:

1. See Division 271250 for model.

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H. Accessories:

1. Surge protection: DITEK Corporation or approved equal.
2. Uninterruptible power supply (UPS) for recording equipment: APC or approved equal.
 - a) See Section 271000 for models

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

1. Provide the CCTV System with all wire, cables, conduit, outlets and equipment as on the drawings and as specified herein.
2. All material and/or equipment necessary for the complete and proper operation of the system, even though not specifically mentioned in the Contract Documents, shall be deemed part of this Contract.
3. All equipment shall be installed and connected in strict accordance with the manufacturer's recommended instructions so as to provide for matched systems for service maintenance from one source, all equipment shall be furnished by one equipment supplier except where indicated

B. Wiring

1. Complete Conduit Raceway System All wiring methods shall be in accordance with NFPA-70, Article 800, and all other codes specified herein. Provide proper number, size of wires and conduit as required for operation of the system in accordance with the manufacturer's instructions. All wiring methods on the system's load side shall be shielded power limited type in conduit as specified in NEC Article 800
2. No wiring other than that directly associated with the system shall be permitted in these conduits.
3. Wiring splices are not allowed.
4. Transposing or changing color coding of wires shall not be permitted
5. All conductors shall be labeled on each end with "E-Z markers" or equivalent
6. Conductors in cabinets shall be carefully formed and harnessed so that each drops off directly opposite to its termination
7. Cabinet terminals shall be numbered and coded All controls, function switches, etc, shall be clearly labeled on all equipment panels
8. All power connections to racks, cameras, devices and equipment shall be made with crimp-type terminal connections, or resin core solder method approved by manufacturer.
9. All wiring shall be checked and tested to insure that there are no grounds, opens or shorts.
10. All cable shields are to be insulated at the "floating" end. Continuity of shield is to be preserved at all connecting points.
11. All audio grounds in any equipment rack, as well as the racks themselves, are to be earth grounded certain coaxial cables shall require cable "isolation transformers" to prevent ground looping.
12. All wiring shall be executed in strict adherence to standard practices. Camera cables and 24 volts AC, and remote wiring to be installed in separate conduits All conduits shall be well spaced from power conduits, and shall be properly grounded to the building grounding electrode system ground Lines in conduit are not to be spliced.
13. All boxes, conduits, etc , shall be of proper size, as determined by the CCTV Systems Trade, shall be clearly marked for easy identification, and continuously grounded together.
14. All equipment except portable equipment shall be firmly held in place. Fastenings and supports shall be adequate to support their loads with a safety factor of at least three. All exterior hardware shall be proper stainless steel or hot-dipped galvanized unless aluminum is encountered.

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15. The CCTV System Trade shall take such precautions as are necessary to prevent and guard against E M I, supply adequate ventilation, and to install the equipment so as to provide reasonable safety for the operator.
 16. The actual circuit routing of the CCTV System shall be by the installing trade based on the location of the devices, circuit limitations and wire limitations.
 17. All co-axial cable, control wiring and power wiring to exterior camera locations shall have surge or transient protectors as required by U L, NEC, TIA and the manufacturers.
- C. Cabinet Equipment Location
1. The video monitors, multiplexers, multiplexer servers and DVR/NVR's shall be installed in the CCTV racks.
 2. The camera power supplies shall be mounted in the top of the rack to avoid overheating and conflicts in the cabinet.

3.2 FIELD QUALITY CONTROL

- A. General: Upon completion of the installation, the CCTV System Trade's factory-trained technician shall perform all necessary electrical tests and adjustments and who shall then submit a Letter of Certification to the Owner/Architect/Engineer that the system functions and conforms to all requirements of the manufacturer of the equipment, these specifications, and all requirements of the building code for the type of building in which the system is installed.
- B. Inspection
 1. The CCTV System Trade shall be responsible for all arrangements for testing and approval of the system before the system is accepted by the Owner and Architect/Engineer.
- C. The factory-trained technician shall perform all electrical and mechanical tests, measurements and adjustments required below. All test costs shall be in the Contract price. A checkout report shall be prepared by the installation technicians and submitted in triplicate. The report shall include, but not be limited to:
 1. A complete list of equipment installed and wired.
 2. Indication that all equipment is properly installed and functions and conforms with these specifications.
 3. Technician's name, certificate number and date.
- D. After completion of all tests, measurements and adjustments listed above, the CCTV System Trade shall submit the following information to the Architect/Engineer:
 1. "As-built" conduit layout diagrams including wire color code and/or tag number.
 2. Complete "as-built" wiring diagrams.
 3. Complete operating and programming instructions, including engineering data sheets on each major component and complete servicing data including part numbers of the various components.

3.3 TESTING

- A. CCTV Equipment
 1. The contractor shall test all equipment for proper signal transmission based on manufacturer standards.
 2. The contractor shall record remove any cable that does not meet manufacturer standards and replace it with a correctly functioning cable.
 3. The contractor shall demonstrate that the installed cables meet manufacturer standards for signal transmission prior to the job being considered complete.
- B. Devices and Equipment

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1. The contractor shall test all aspects of the system once it is installed and demonstrate these functions to the owner or owner's representative.
 - a) Devices shall be verified to function individually and as a unit
 - b) Devices shall be demonstrated to work as intended by the manufacturer.

3.4 PROGRAMMING

- A. All aspects of the system shall be fully programmed and active for owner.
- B. Integration with other systems shall be programmed.
- C. Integration with owner equipment shall be programmed.
 1. Coordinate all programming with the owner and owner's equipment at the time of construction and installation.

3.5 AS-BUILTS

- A. As-builts shall be provided by the contractor in hardcopy and electronic CAD format prior to project completion and inspection. PDFs inserted into CAD documents are not acceptable.
- B. As-builts by contractor must include parts lists and wiring diagrams that clearly indicate all equipment, locations, wiring and connections.
- C. Owner's manuals shall be supplied as part of the as-built documentation.

3.6 DEMONSTRATION AND TRAINING

- A. All aspects of the systems must be demonstrated for the owner at the time of training. A minimum of 16 hours of training shall be provided.
- B. Training shall be video and audio recorder for the owner and turned over to the owner at acceptance.

3.7 ACCEPTANCE

- A. Contractors work shall be considered complete after the following conditions have been met:
 1. Cable installation is complete and all cable runs have been tested and documented to be installed according to specifications and drawings.
 2. Equipment installation is complete and all functions have been tested and documented to function as designed and per the manufacturer's recommendations.
 3. All punch list items have been reconciled.
 4. All disturbed ceiling panels, fire stopping materials, covers, etc. have been properly reinstalled.
 5. All materials and trash have been removed from the site.
 6. A 2-Year Installers warranty has been given to a school district Technology/Security representative.
 7. Submit Manufacturer's Warranty Application.

END OF SECTION

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SECTION 283111 - FIRE DETECTION AND ALARM SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

- A. Contractor shall provide and install an extension to an existing microprocessor based fire alarm and detection system. The new components shall be the product of a single manufacturer of established reputation and experience. Installation shall include all parts, labor, software and hardware necessary to affect a complete installation.
- B. In addition to the requirements of this section, the electrical and fire alarm contractors shall review the mechanical drawings for quantities and locations of fire alarm devices such as smoke detectors, heat detectors, smoke dampers, etc.
- C. The complete set of Architectural, Structural, Civil, Mechanical, and Electrical drawings, specifications, and addenda apply to this work.

1.2 REQUIREMENTS

- A. The latest editions of the following codes and standards shall govern work performed under this section:
 - 1. Maryland State Fire Prevention Code (COMAR 29.06.01 and 29.06.02)
 - 2. NFPA 101 - Life Safety Code
 - 3. International Building Code (IBC)
 - 4. International Fire Code (IFC)
 - 5. NFPA 70 - National Electrical Code
 - 6. NFPA 72 - National Fire Alarm Code
 - 7. NFPA 80 - Fire Doors and Windows
 - 8. NFPA 90A - Installation of Air Conditioning and Ventilating Systems
 - 9. NFPA 13 - Standard for installation of sprinklers
 - 10. Americans with Disabilities Act (ADA)
 - 11. Baltimore County Fire Prevention Code, County Bill No. 63-13
 - 12. Baltimore County Building Code, Bill No. 40-12

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1.3 RELATED SECTIONS

- A. Division-08 Section - Door Hardware: Door closers, electric locks, electric releases.
- B. Division-21 Section - Fire Protection.
- C. Division-23 Section - Ductwork Accessories: Smoke dampers.
- D. Division-26 Section - Raceways.
- E. Division-26 Section - Wires and Cables.
- F. Division-26 Section – Boxes, Fittings and Cabinets.

1.4 SYSTEM DESCRIPTION

A. Initiating Devices:

- 1. Provide manual stations within five feet (1500 mm) of each exit along the normal path of egress travel, along the egress path as required to ensure that travel distance to any manual station does not exceed 200 feet (60 m), and where required by NFPA 72.
- 2. Provide analog smoke detectors outside each elevator door, inside each elevator machine room and elevator shaft, and at each door hold open device as required by NFPA 72.
- 3. Provide analog smoke detectors at the top and bottom of each elevator shaft when the elevator shaft is protected by a sprinkler system.
- 4. Provide analog duct smoke detectors, sampling tube, housing and mounting equipment and connect to system to initiate supervisory signal and shutdown respective air handlers as required by NFPA 90A.
- 5. Supply interface monitor modules for automatic sprinkler system waterflow switches and connect to the system to initiate alarm signal.
- 6. Supply interface monitor modules for automatic sprinkler system valve tamper switches and pressure switches and connect to system to initiate supervisory signal.
- 7. Provide heat detectors at the top and bottom of each elevator shaft when the elevator shaft is protected by a sprinkler system. Provide a heat detector within two feet (600 mm) of each sprinkler head.
- 8. Provide heat detectors in elevator machine rooms when the elevator machine room is protected by a sprinkler system. Provide a heat detector within two feet (600 mm) of each sprinkler head.

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9. Supply interface monitor modules for fire pump alarms. Provide a separate module for each alarm: pump running, loss of power in any phase and phase reversal.
 10. Provide labeling on all initiating devices indicating its programmed address.
- B. Notification Appliances:
1. Provide combination speaker/strobe signals throughout as required to ensure audibility and intelligibility of signal as detailed in NFPA 72.
 2. Provide additional non-textual visual appliances throughout building to ensure all signals are visible to all occupants as required by the ADA.
- C. Auxiliary Functions:
1. HVAC Shutdown - Shut down respective air handler upon activation of associated duct smoke detector(s).
 2. Door Holders - Release doors automatically upon activation of associated smoke detector(s).
 3. Elevator Recall - Control modules shall be installed in all elevator machine rooms. Elevators with recall capability shall be connected to the control modules to provide elevator recall. Elevators without recall capability shall not be connected, but control modules shall be installed for future use.
 4. Elevator Disconnects - Heat detectors located in elevator machine rooms and at the top and bottom of elevator shafts shall be connected to automatically open the elevator disconnect(s).
 5. Smoke Dampers - Close respective smoke damper upon activation of associated duct smoke detector(s).

1.5 QUALITY ASSURANCE

- A. The system and all components shall be listed by Underwriters Laboratory for fire protective signaling service (local and remote station, emergency communication and relocation equipment, protective signaling systems) under UL 864. Automatic detectors, manual stations, sprinkler system alarm attachments, control unit accessories, indicating appliances and all other alarm system attachments shall be listed, labeled and approved for use with the specified control equipment. Visual indicating appliances shall be listed and labeled under UL 1971, "Signaling Devices for the Hearing Impaired".
1. Equipment Not Described: The Drawings and Specifications are schematic only and are not intended to relieve the Contractor from responsibility for furnishing all material, equipment and labor required to affect proper system operation. System subassemblies, software, programming, hardware, interface devices, controls, tools, test equipment and related devices vary considerably among manufacturers and cannot be fully described without reducing competition.

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2. Manufacturer/Distributor Support: The Contractor shall confirm to the satisfaction of the Owner that a factory authorized support organization exists within close proximity to the site. Such organization shall be adequately stocked with equipment, parts and accessories, and adequately trained and capable to perform all required engineering, maintenance and testing support necessary to ensure continued efficient and effective system operation.

1.6 SUBMITTALS

- A. Shop drawing and product data approval shall be obtained from the Engineer and Fire Marshall prior to commencing system installation. Submit shop drawings and product data as required for review and approval. Following substantial completion, operations and maintenance data and record drawings shall be submitted to the Owner.
 1. Shop drawings shall include a building floor plan indicating the location of all zones, system devices and components, a wiring riser diagram, panel wiring diagram, device wiring details, listing of device addresses, sequence of operation and battery calculations. Drawings shall clearly indicate the height and location of all equipment, devices, wiring, conduit and junction boxes. Drawings shall be clean, neat, professionally prepared by CADD or manual drafting.
 2. Statement of Compliance and Deviation:
 - a. The submittal package shall include a copy of these specifications with each sub-paragraph noted with the comment "Compliance", "deviation", or "alternate".
 - b. By noting the term "compliance", it shall be understood that the manufacturer is in full compliance with the item specified and will provide exactly the same with no deviations.
 - c. By noting the term "deviation", it shall be understood that the manufacturer prefers to provide a different component in lieu of that specified. Manufacturer shall indicate all deviations.
 - d. By noting the term "alternate", it shall be understood that the manufacturer proposes to provide the same operating function but prefers to do it in a different manner. Any alternate shall be fully described as to what the manufacturer proposes to provide.
 3. Installation Instructions: Manufacturer's installation guide and programming instructions shall be submitted with the shop drawings.
 4. Operations and Maintenance Data: Manufacturer's operating instruction and maintenance manuals, installation instructions and programming guides shall be supplied to Owner and his representatives within fifteen (15) days of substantial completion. Five (5) copies of each manual shall be provided.
 5. Installer's UL Certificate: Provide a copy of the UL certificate or equivalent evidence that the fire alarm contractor is listed by UL or a NRTL for installation and

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maintenance of "Protective Signaling Systems."

6. Record Drawings: All deviations from the approved shop drawings require prior approval of the Engineer. Within fifteen (15) days of substantial completion, record drawings indicating the location and configuration of all equipment, devices, wiring, conduit and junction boxes shall be supplied to the owner. Five (5) copies of each drawing shall be provided. Drawings shall be clean, neat, professionally prepared by CADD or manual drafting.
7. Computer (CADD) files of electrical drawings will not be made available to the Contractor for any purposes.

1.7 SPARE PARTS

- A. Contractor shall supply the Owner with a minimum of one (1) replacement for each six (6) devices (or fraction thereof) installed of the following devices:
 1. Analog Smoke Detectors
 2. Manual Stations
 3. Interface Monitor Modules
 4. Interface Control Modules
 5. Speaker/Strobe Signals
 6. Strobe Signals
 7. Duct Smoke Detector
 8. Door Hold Open Devices
 9. Heat Detectors
 10. Speakers
 11. Amplifiers
 12. Telephone Handsets

1.8 PROGRAMMING AND TEST DEVICES OR TOOLS

- A. Contractor shall furnish all devices necessary to conduct tests of all devices and equipment prior to substantial completion. Upon satisfactory completion of required tests, the contractor shall furnish the owner with two of each device, tool or accessory used and required to perform complete periodic tests and maintenance. Such devices or tools may include interface devices, interface module programming tools, keys, program codes, software and the like. These devices, tools and accessories shall become the property of the Owner.

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PART 2 - PRODUCTS

2.1 ALARM INITIATING DEVICES

- A. Alarm initiating devices shall consist of addressable detectors and manual stations. These devices shall be listed and approved for use with the control equipment specified.
 - 1. Analog smoke detectors shall be addressable, ionization (or photoelectric where indicated on the Drawings), plug-in type with base. The detector base shall be of the twist/lock type with screw terminals for field wiring. An automatic gain control circuit shall be provided to compensate for detector aging and dirt accumulation and maintain the detector within the correct sensitivity range. A critical reduction of sensitivity caused by dirt accumulation shall initiate a trouble signal. Detector sensitivity shall be capable of being read and adjusted from the control panel.
 - 2. Interface monitor modules shall be addressable, mounted in standard 4" x 4" (100 mm x 100 mm) square or octagonal electrical boxes with covers. Cover shall be labeled or embossed with fire alarm system interface module designation. A solid state LED indicator lamp shall be visible in the cover. These modules are to be used for connection of conventional alarm devices such as waterflow switches, valve tamper switches, sprinkler pressure switch, fire pump alarms and other non-addressable devices. Connections between devices and modules shall be integrally supervised for open and ground faults. Monitor and control functions may be integrated in a single interface module if listed and approved for this purpose.
 - 3. Duct type detector assemblies shall consist of an addressable analog photoelectric detector, an air duct sampling tube and detector housing. Provide a remote test station with alarm indicating lamp for all duct detectors installed in concealed spaces.
 - 4. Manual stations shall be addressable, red in color, non-coded, double-action, non-break glass type. Manual station covers shall be hinged and secured with a lockset. Lockset shall be keyed the same as the control unit lockset. Provide all manual stations with STI brand protective covers.
 - 5. Heat detectors shall be addressable, plug-in type with base. The detector base shall be of the twist lock type with screw terminals for field wiring. Detectors shall be rate-compensation, fixed temperature type, rated at 135 °F (57°C). Detector element shall be self-restoring after operation.
 - 6. Contractor shall include 5 analog smoke detectors, 4 duct type smoke detectors, and 4 heat detectors inclusive of associated labor (including circuit ring-out and programming) and material to install after final walk-thru by Fire Marshal. Devices shall be installed in locations as directed by Fire Marshal and shall include all cutting, patching and finishing of walls. All unused devices shall be turned over to the owner for use as spares.

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2.2 NOTIFICATION APPLIANCES

- A. Alarm indicating appliances for areas where voice alarm is required shall consist of audible and visual signals for public signaling of fire. The primary signaling scheme shall consist of speaker/strobes transmitting a tone followed by a prerecorded custom message. In the public address mode, voice/alarm signaling functions will be overridden to transmit the public address message.
 - 1. Speaker/strobes shall have semi-flush mounted with red covers and clear strobe lens. Speaker/strobe signals shall comply with the requirements of the ADA and NFPA 72, Chapter 6.
 - 2. Strobe units shall consist of a red cover and clear lens. Strobe signals shall comply with the requirements of the ADA and NFPA, Chapter 6.
- B. Strobes shall provide a minimum effective intensity of candela levels listed on the contract drawings. Strobes shall be listed to 1971 Standard Underwriter Laboratories.
- C. Alarm indicating appliances to be installed on the exterior of the building shall be weatherproof and listed for outdoor use.
- D. Contractor shall include 5 audible 5 visual and 5 combination audible/visual devices inclusive of associated labor (including circuit ring-out and programming) and material to install after final walk-thru by Fire Marshal. Devices shall be installed in locations as directed by Fire Marshal and shall include all cutting, patching and finishing of walls. All unused devices shall be turned over to the owner for use as spares.

2.3 AUXILIARY DEVICES

- A. Magnetic door holders shall be used to hold fire or smoke doors in the open position during normal operation. Upon activation of smoke detectors located immediately adjacent to the door opening, the door holders release, allowing the doors to close automatically. Detectors initiating this function shall be located and installed in accordance with NFPA 80. Door holders shall be listed and approved for the intended use, and connected to the control panel by an addressable interface module (control).
- B. Interface control modules shall be addressable, mounted in standard 4" x 4" (100 mm x 100 mm) square or octagonal electrical boxes with covers. Cover shall be labeled or embossed with fire alarm system interface module designation. A solid state LED indicator lamp shall be visible in the cover. These modules are used for control of auxiliary functions such as elevator recall, fan shutdown, sprinkler system electric water gong, and door holder release. Interface modules shall be equipped with form "C" dry-contacts rated 2A, 125 VAC or 2A, 30 VDC resistive. Monitor and control functions may be integrated in a single interface module if listed and approved for this purpose.

2.4 GRAPHIC ANNUNCIATOR PANELS

- A. Graphic annunciator panels shall be minimum 24" x 30" (600 mm x 750 mm), with white photo-emulsion graphics in smoked plexiglass and LCD display. The panel shall include

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an outline of each zone and shall utilize backlit displays to indicate alarm types and locations.

- B. The fire alarm control panel or annunciator panels shall include, but in no way be limited to, the following alarms, controls and status indicators:
1. Alarm, trouble and power-on for system.
 2. Alarm type and location for each zone.
 3. Trouble for each zone.
 4. Run and trouble indicators for standby generator.
 5. Run, trouble, phase reversal indicators for fire pump.
 6. Auto/run switch for fire pump.
 7. Run/auto/off switches for smoke exhaust fan.
 8. Run/auto/off switch for stair pressurization fan.
 9. Run/auto/off switch for corridor pressurization fan.
 10. Run/auto/off switch for smoke exhaust system for each zone.
 11. On indicators for smoke exhaust fan, stair pressurization fans, corridor pressurization fan, general exhaust fan, basement mechanical room ventilation fan and smoke exhaust system whether activated automatically or manually.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Division-26 Section, Basic Electrical Materials and Methods for general execution requirements.
- B. Smoke detectors shown on the Drawings indicate areas where smoke detectors shall be installed. The location and quantity of smoke detectors shall be in accordance with NFPA 72 and the UL Listing for the specific devices.
- C. Heat detectors shown on the Drawings indicate areas where heat detectors shall be installed. The location and quantity of heat detectors shall be in accordance with NFPA 72 and the UL Listing for the specific devices.
- D. Duct smoke detectors shall be installed in accordance with manufacturer's written instructions. Detectors shall be readily accessible for cleaning and testing. Provide access panels or doors if necessary. Provide duct detectors on both the supply and return of all air handling units provided under this contract unless otherwise noted.

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- E. Interface modules (monitor and control) shall be located within 3 feet (75 mm) of the device it is monitoring or controlling.
- F. Strobes shall be installed with the bottom of the appliance 80 inches (2000 mm) above the finished floor or 6 inches (150 mm) below the finished ceiling, whichever is lower.
- G. Manual stations shall be installed with the top of the device 48 inches (1200 mm) above the finished floor.
- H. Coordinate connection of smoke dampers with mechanical contractor. Make special efforts to communicate and review fire alarm system voltage (24V) with mechanical contractor for smoke damper voltage.
- I. Coordinate connection to 24 volt sprinkler system electric motor gong with sprinkler system contractor to ensure gong is only operated upon sprinkler pressure switch sensing a fluctuation in water pressure. Sprinkler electric water gong shall be powered from the fire alarm system by a fully supervised circuit. Provide power supervisory relay and monitoring module as required to provide this supervision.
- J. Provide supervision of electrical circuits serving heat tracing used on sprinkler piping per NFPA 13, section 8.16.4.1.4.2. Provide positive confirmation that circuit is energized. Provide supervisory signal at FACP upon loss of power to heat trace system.

3.2 QUALIFICATIONS

- A. System installation shall be supervised by an experienced fire alarm technician with not less than five (5) years' experience with fire alarm systems. All field installation work shall be continuously supervised by a NICET Level II or III fire alarm system technician.
- B. Fire alarm system shall be installed and maintained by a listed fire alarm contractor, listed by UL for installation and maintenance of "Protective Signaling Systems" or other NRTL. The fire alarm contractor shall meet all UL requirements and provide a copy of the UL certificate to the Fire Marshal.
- C. The Contractor installing the fire alarm system shall provide a copy of the UL certification or FM placard to the Baltimore County Fire Marshal's Office for the newly installed system.

3.3 CHANGES

- A. The technician supervising field work shall promptly notify the engineer of any changes or deviations from the contract drawings and specifications necessitated by field conditions.

3.4 WIRING

- A. All field wiring shall be installed in conduit. Conduit and boxes shall be sized according to National Electrical Code requirements based on the number of conductors. Initiating

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device circuit wiring shall be two-conductor twisted with integral shield and ground. Indicating appliance circuits shall be minimum 14 AWG. Primary power (AC) branch circuit conductors shall be minimum 12 AWG. Address loop circuits shall be a minimum of 18 AWG.

- B. Fire alarm circuits shall be identified by red junction box covers stenciled in white letters "FIRE ALARM."
- C. Fire alarm wiring shall be color coded in accordance with requirements of local Authority Having Jurisdiction.
- D. The addressable loop shall be wired Class B, Style 4. The initiating devices shall be wired Class B, Style B. The notification appliances shall be wired Class B, Style Y. Where transponder panels are required, wiring from control panel through the transponder panels shall be Class A, Style 6.
- E. All wiring shall be tested for the following conditions before devices are installed or circuits connected to control equipment:
 - 1. Verify that stray (unwanted) voltages do not exist between the installation conductors and ground or between conductors.
 - 2. Verify all conductors not intentionally grounded are isolated from ground using an approved insulation testing device or "megger."
 - 3. Verify that all conductors not intentionally connected together are isolated from one another using an approved insulation testing device or "megger."
 - 4. Measure and record the loop resistance of each circuit with the conductor pair shorted together at the far end, verify that loop resistance does not exceed manufacturer's requirements.
- F. Supply the Owner and Engineer with a copy of all circuit testing reports and loop resistance readings.

3.5 SYSTEM TESTING

- A. All initiating and indicating appliances, control equipment, accessories and auxiliary functions shall be tested in accordance with NFPA 72 acceptance test procedures. Representatives of the Owner, Engineer and local Fire Marshal shall be notified of the date and time of the test. A minimum of fourteen (14) days' notice is required when scheduling the acceptance test. The Contractor is responsible for conducting all required tests. All necessary equipment and supplies shall be provided at Contractor's expense, including ladders, radios, test equipment, volt-ohm meter, sound-pressure (decibel) meter, flashlights, hand tools and smoke or smoke substitute for functional tests. All test procedures shall conform to the manufacturer's recommended test procedures and the NFPA 72 recommended practice. Subcontractors responsible for related work connected to or controlled by the fire detection and alarm system shall be available to demonstrate their equipment at the time of acceptance testing.

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ADDITION / RENOVATION

- B. Testing of indicating appliances shall be scheduled in accordance with Owner requirements.

3.6 TEST REPORT

- A. The Contractor shall prepare and submit a test report in the form and content required by NFPA 72. The report shall be signed by the supervising technician or fire protection engineer. The Contractor shall submit the report to the Owner and his representatives, upon completion of testing.

3.7 WARRANTY

- A. The completed system shall be warranted for a period of two (2) years from the date of acceptance. The warranty shall cover all defects in parts and workmanship, and expenses related to parts, labor and travel to and from the site for the purposes of correcting same. Maintenance and repair shall be performed only by a factory trained service technician.

3.8 TRAINING

- A. Contractor shall arrange and furnish training for Owner's representatives. This training shall include instruction in proper system maintenance, test and troubleshooting procedures. Provide a minimum of eight (8) hours of training.

3.9 PROJECT CLOSEOUT

- A. See Section 260200, "Project Closeout – Electrical", for more requirements.

END OF SECTION 283111

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SECTION 311000 - SITE CLEARING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Charles County Government Department of Planning and Growth Management Specifications and details dated July, 1995, revised December 1999 and as amended.
- C. Maryland Department of Transportation State Highway Administration Standard Specifications for Construction and Materials, dated January, 2008 and as amended.

1.2 SUMMARY

- A. This Section includes the following:

1. Protection of existing trees indicated to remain.
2. Removal of trees and other vegetation.
3. Topsoil stripping.
4. Clearing and grubbing.
5. Removing below-grade improvements pertains to those items shown on the drawings, and those associated with the above grade improvements to be removed, if they impede the proposed work.
6. Removal and/or abandonment of utilities and appurtenances.

1.3 PROJECT CONDITIONS

- A. Traffic: Conduct site-clearing operations to ensure minimum interference with roads, streets, walks, and other adjacent occupied or used facilities. Do not close or obstruct streets, walks, or other occupied or used facilities without permission from authorities having jurisdiction.
- B. Protection of Existing Improvements: Provide protections necessary to prevent damage to existing improvements indicated to remain in place.
 1. Protect improvements on adjoining properties and on Owner's property.
 2. Restore damaged improvements to their original condition, as acceptable to property owners, in a timely manner and at no additional cost to the Owner.
- C. Soil Erosion and Sediment Control: Soil erosion and sediment control measures are required for this site in accordance with the approved plans. Soil erosion and sediment control measures disturbed or damaged by clearing operations shall be restored to operating condition in accordance with the requirements of the approved plan before the end of the work day.
- D. Protection of Existing Trees and Vegetation: Protect existing trees and other vegetation indicated to remain in place against unnecessary cutting, breaking or skinning of roots, skinning or bruising of bark, smothering of trees by stockpiling construction materials or excavated materials within drip line, excess foot or vehicular traffic, or parking of vehicles within drip line. Provide temporary guards to protect trees and vegetation to be left standing.

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1. Water trees and other vegetation to remain within limits of contract work as required to maintain their health during course of construction operations.
 2. Provide protection for roots over 1-1/2 inch in diameter that are cut during construction operations. Coat cut faces with an emulsified asphalt or other acceptable coating formulated to use on damaged plant tissues. Temporarily cover exposed roots with wet burlap to prevent roots from drying out, cover with earth as soon as possible.
 3. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations in manner acceptable to Architect. Employ a licensed arborist to repair damage to trees and shrubs.
 4. Replace trees that cannot be replaced and restored to full-growth status, as determined by arborist.
- E. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated or directed.

1.4 EXISTING SERVICES

- A. General: Indicated locations are approximate, determine exact locations before commencing Work.
- B. Arrange and pay for disconnecting, removing, capping, and plugging, utility services. Notify affected utility companies in advance and obtain approval before starting this Work.
- C. Place markers to indicated location of disconnected services. Identify service lines and capping locations on Project Record Documents.

1.5 QUALITY ASSURANCE

- A. Comply with standards of authorities having jurisdiction.
- B. In the event of a discrepancy between the Project Specifications, Construction Documents, Charles County Standard Specifications and Details, or other guidelines set forth by the authorities having jurisdiction, the more stringent will apply.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 SITE CLEARING

- A. The contractor shall review the Construction Managers construction staging plan prior to beginning any construction.
- B. General: Remove trees, shrubs, grass, and other vegetation, improvements, or obstructions, as required, to permit installation of new construction. Remove similar items elsewhere on site or premises as specifically indicated. Removal includes digging out and off-site disposal of stumps and roots.
 1. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
- C. Topsoil: Topsoil is defined as friable clay loam surface soil found in a depth of not less than 6 inches. Satisfactory topsoil is reasonably free of subsoil, clay lumps, stones, and other objects over 1 inch in diameter, and without weeds, roots, and other objectionable material.

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1. Strip topsoil to whatever depths encountered in a manner to prevent intermingling with underlying subsoil or other objectionable material. Remove heavy growths of grass from areas before stripping.
 - a. Where existing trees are indicated to remain, leave existing topsoil in place within drip lines to prevent damage to root system.
 2. Stockpile topsoil in storage piles in areas indicated or directed. Construct storage piles to provide free drainage of surface water. Cover storage piles, if required, to prevent wind erosion.
 3. Dispose of unsuitable as specified in Section 312300 – Excavating and Filling for disposal of waste material.
- D. Clearing and Grubbing: Clear site of trees, shrubs, and other vegetation, except for those indicated to be left standing.
1. Completely remove stumps, roots, and other debris protruding through ground surface.
 2. Use only hand methods for grubbing inside drip line of trees indicated to remain.
 3. Fill depressions caused by clearing and grubbing operations with satisfactory soil material, unless further excavation or earthwork is indicated.
 - a. Place fill material in horizontal layers not exceeding 8 inches loose depth, and thoroughly compact each layer to a density not less than 95 percent of the maximum dry density when tested in accordance with AASHTO T-180 within the building footprint and extending out ten feet (10') either side of the exterior wall lines. Beyond this zone, fill may be compacted to a density not less than 92 percent of the maximum dry density when tested in accordance with AASHTO T-180.
- E. Removal of Improvements: Remove existing above-grade and below-grade improvements as indicated and as necessary to facilitate new construction.
1. Removal of pavement, including base courses, sidewalk, curb, and combination curb and gutter, shall be for the full depth thereof.
 2. The Contractor shall use suitable equipment, tools, and methods for cutting and trimming as well as removing the materials to the neat lines set by the Owner and shall not in any manner disturb or damage the sections of base or pavement to be salvaged.
 3. Damage done by the Contractor's equipment or methods to those areas designated for salvaging shall be replaced at the Contractor's expense.
 4. Where the old subgrade is satisfactory as to condition and elevation, special care shall be taken in the removal operation in order to avoid the disturbing of the old grade.
 5. Abandonment or removal of certain underground pipe or conduits may be indicated on mechanical or electrical drawings and is included under work of related Section 024113. Removing abandoned underground piping or conduits interfering with construction shall be as follows:
 - a. Underground improvements shall be completely removed to a depth of two feet below indicated subgrade under structures and paving or finished grade in other areas or where it conflicts with proposed construction.
 - b. Pipes and other utilities indicated to be abandoned in place shall have open ends

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plugged with concrete for a minimum length of one foot. Structures, manholes, and other utility appurtenances shall be filled with compacted subgrade materials.

6. Fill depressions caused by clearing and grubbing and removal of improvements with satisfactory material, unless further excavation or earthwork is indicated.

3.2 DISPOSITION OF UTILITIES

- A. Verify with the Authority having jurisdiction that utility lines indicated to be removed or abandoned are no longer in service before beginning removal or abandonment.
- B. Relocation of Utilities: Where utility services (which include water, sewer, storm drains, electrical, gas, telephone, etc.) are to be relocated as a part of the work of this contract, the Contractor shall maintain the existing utility services in service until the relocated services have been completed and approved. The Contractor shall coordinate with the Authority having jurisdiction to make temporary service connections, re-route services and make tie-ins all as may be required.
- C. Unknown Utilities: Where utilities are encountered in the work, the presence of which is not shown or indicated on the drawings, the Contractor shall immediately notify the Authority having jurisdiction. Following notification the Contractor shall maintain these unknown utility services until instructed by the Authority having jurisdiction as to the proper disposition of the utility.

3.3 DISPOSAL OF WASTE MATERIALS

- A. Burning on Owner's Property: Burning is not permitted on Owner's property.
- B. Removal from Owner's Property: Remove waste materials and unsuitable topsoil from Owner's property and dispose of off-site in accordance with local regulations.

3.4 RECORD DRAWINGS

- A. Survey and include on record drawings location and depth of all utilities encountered which have not been removed.

END OF SECTION 311000

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SECTION 312300 - EXCAVATING AND FILLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Charles County Government Department of Planning and Growth Management Specifications and details dated July, 1995, revised December 1999 and as amended.
- C. Maryland Department of Transportation State Highway Administration Standard Specifications for Construction and Materials, dated January, 2008 and as amended.

1.2 DESCRIPTION

A. This Section includes the following:

1. Backfilling operation to bring the existing site to grade.
2. Preparing and grading sub grades to slabs-on-grade, walks, pavements, and landscaping.
3. Excavating and backfilling for buildings and structures.
4. Drainage and moisture -control fill course for slabs-on-grade.
5. Subbase course for walks and pavements.
6. Subsurface drainage backfill for walls and trenches.
7. Excavating and backfilling trenches within building lines.
8. Excavating and backfilling for underground utilities and appurtenances.

B. Related Sections:

1. Section 017700: Closeout Procedures
2. Section 033000: Cast-in-Place Concrete
3. Section 311000: Site Clearing
4. Section 329000: Planting

1.3 DEFINITIONS

- A. Excavation consists of the removal of material encountered to subgrade elevations and the reuse or disposal of materials removed.
- B. Subgrade: The uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.
- C. Borrow: Soil material off-site when sufficient approved soil material is not available from on-site excavations.
- D. Subbase Course: The layer between the subgrade and base course in a paving system or the

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layer placed between the subgrade and surface of a pavement or walk.

- E. Base Course: The layer placed between the subbase and surface pavement in a paving system.
- F. Drainage Fill: Course of washed granular material supporting slab-on-grade placed to cut off upward capillary flow of pore water.
- G. Unauthorized excavation consists of removing materials beyond indicated subgrade elevations or dimensions without direction by the Architect. Unauthorized excavation, as well as remedial work directed by the Architect, shall be at the Contractor's expense.
- H. Additional excavation: When excavation has reached required subgrade elevations, notify the Inspection Agency, who will make an inspection of conditions. The Contractor is responsible for scheduling the inspections such that there is no delay in the Project. If the Inspection Agency determines that bearing material at required subgrade elevations are unsuitable, continue excavation until suitable bearing materials are encountered and replace excavated material as directed by them.
- I. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below ground surface.
- J. Utilities include on-site underground pipes, conduits, ducts, and cable, as well as underground services within building lines.
- K. Rock excavation will include excavation of materials that can not be dislodged by rock excavating equipment as defined herein. Rock excavating equipment for open excavations shall be equivalent to Caterpillar Model No. D-8N, heavy duty track type tractor, rated at not less than 285 hp flywheel power and equipped with a single shank hydraulic ripper, capable of exerting not less than 45,000 lbs. breakout force.
 - a. Rock materials include boulders $\frac{1}{2}$ cu. yd. or more in volume and rock in beds, ledges, unstratified masses and conglomerate deposits.
 - b. Excavations more than 10 feet in width and pits more than 30 feet in either length or width are defined as open excavations.
 - c. Rock excavation for footings, trenches and pits shall be equivalent to Caterpillar Model No. 215-LC track-type hydraulic excavator, equipped with a 42" wide short-tip radius rock bucket, rated at not less than 120 hp flywheel power with bucket curling force of not less than 25,000 lbs. and stick-crowd force of not less than 18,000 lbs.
 - d. The Contractor shall provide the Owner with rock surface elevations for quantity verification prior to any rock removal.

1.4 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for the following:
 1. Each type of warning tape.
- C. Test Reports: In addition to test reports required under field quality control, submit the following:
 1. Laboratory analysis of each soil material proposed for fill and backfill from on-site and borrow sources.

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2. One moisture density curve for each soil material.
 3. Reports of actual unconfined compressive strength and/or results of bearing tests of each stratum tested.
- D. Final project "as-built" record documents in accordance with Specification section 017700 – Contract Closeout.

1.5 QUALITY ASSURANCE

- A. Codes and Standards: Perform earthwork complying with requirements of Charles County.
- B. Testing and Inspection Service: The Owner will employ a qualified independent geotechnical engineering testing agency to classify proposed on-site and borrow soils to verify that soils comply with specified requirements and to perform required field and laboratory testing during earthwork operations. Check bearing capacities of excavated footings to confirm bearing capacity prior to installation of reinforcing steel and concrete.
- C. In the event of a discrepancy between the Project Specifications, Construction Documents, Charles County requirements, or other guidelines set forth by the authorities having jurisdiction the more stringent will apply.

1.6 PROJECT CONDITIONS

- A. Backfilling below-grade areas: The backfilling operation required to bring actual grades to the grade elevations shown on the drawings as proposed grades.
 1. The borrow material shall be removed and then either stored or disposed. If the testing agency verifies that the borrow material complies with these specifications for backfill material, then the Contractor may use it to backfill this area to grade.
 2. Note that high or low moisture contents do not render a soil as "unsuitable" as the contractor is wholly responsible for moisture conditioning of the soils (i.e., scarifying/loosening and wetting or drying). Undercuts will only be authorized if the soils remain unsuitable when the soil in question is at optimal moisture content.
 3. All suitable materials removed in excavation shall be used in accordance with the provisions of this section. It shall be the obligation of the Contractor to utilize all suitable materials from excavation in the construction of fills throughout the entire area of the Contract.
 4. Any additional backfill material necessary to complete this operation shall comply with these specifications.
 5. This backfilling operation shall be the first earthwork operation performed on site after establishment of the sediment control devices.
- B. Site Information: Data in subsurface investigation reports was used for the basis of the design. The data in the subsurface investigation report is not a part of the Contract. Conditions are not intended as representations or warranties of accuracy or continuity between soil borings. The Owner, Architect or Engineers will not be responsible for interpretations or conclusions drawn from this data by the Contractor.
 1. Additional test borings and other exploratory operations may be performed by the Contractor, at the Contractor's option; however, no change in the Contract Sum will be authorized for such additional exploration.

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- C. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted in writing by the Architect and then only after acceptable temporary utility services have been provided. If existing utilities are indicated to be abandoned, the Contractor shall remove such utility, if necessary, at no additional cost to the Owner.
 - 1. Provide a minimum 48-hours notice to the Architect and receive written notice to proceed before interrupting any utility.
- D. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shutoff services if lines are active.
- E. Should uncharted or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.
- F. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights. Open trench excavations within the limits of the State right-of-way shall be protected in accordance with the requirements of applicable permits. Open excavation within the roadways shall be plated and shall be posted with warning devices in accordance with the Manual of Uniform Traffic Control Devices.
 - 1. Perform excavation by hand within dripline of large trees to remain. Protect root systems from damage or dryout to the greatest extent possible. Maintain moist condition for root system and cover exposed roots with moistened burlap.
- G. Moisture Sensitive Soils:
 - 1. The on-site founding materials are moisture sensitive and will be easily disturbed by excessive construction activity.
 - 2. The exposed founding materials shall be protected against detrimental changes in engineering qualities as a result of disturbance from rain or frost.
 - 3. Surface runoff shall be drained away from the excavations and not allowed to pond.
 - 4. If possible, concrete shall be placed in the footings the same day the excavations are made, or the founding materials may be covered by mud mats in order to protect the founding soil from becoming saturated due to forecasted precipitation and/or disturbed due to excessive construction activity during the placement of steel reinforcement.
 - 5. The presence of moisture sensitive fine-grained soils poses the potential for high moisture content. Soils may be found to be at or near their plastic limit; consequently, the on-site soils may require dicing, aeration, and/or manipulation to achieve efficient compaction.
 - 6. Any regions exhibiting poor drainage characteristics, and low lying areas, shall be expected to display moisture contents, which are excessively high for normal earthwork operations.
 - 7. Note that high or low moisture contents do not render a soil as "unsuitable" as the contractor is wholly responsible for moisture conditioning of the soils (i.e., scarifying/loosening and wetting or drying). Undercuts will only be authorized if the soils remain unsuitable when the soil in question is at optimal moisture content.
 - 8. All suitable materials removed in excavation shall be used in accordance with the provisions of this section. It shall be the obligation of the Contractor to utilize all suitable materials from excavation in the construction of fills throughout the entire area of the

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- Contract.
9. Any standing water shall be drained or pumped into approved sediment control facilities prior to commencement of earthwork.
 10. Excavations near to subgrade and all fills should be protected from traffic of heavy equipment, including heavy compaction equipment, when on-site soils exhibit high moisture contents, in order to minimize pumping and a generalized deterioration of these materials.
- H. The Contractor is solely responsible for the protection of the sub-grade until it receives final surface treatment and shall maintain the sub-grade as suitable and acceptable to the Owner or Owner's Representative at all times. He shall be completely responsible for restoration or replacement of the sub-grade due to moisture damage, construction traffic, or any other cause. Repair or replacement of the sub-grade shall be performed at no additional cost to the Owner.
- I. Rock Excavation: The Contractor shall provide the Owner with rock surface elevations for quantity verification prior to any rock removal.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide approved borrow soil materials from off-site when sufficient approved soil materials are not available from excavations. Classification of materials shall be made by the Contractors independent testing agency.
- B. Satisfactory Soil Materials: ASTM D 2487 soil classification as SM or GM soils with a liquid limit and plasticity index of less than 40 and 10 respectively, and an AASHTO T-180 compacted maximum dry density of at least 110 PCF; free of rock or gravel larger than 2 inches in any dimension and 1.5 inches within the top 18 inches of fill, debris, waste, frozen materials, vegetation and other deleterious matter.
- C. Backfill and Fill Materials: Satisfactory soil materials.
- D. Subbase and Base Material: naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand, ASTM D 2940. Graded aggregate for subbase courses shall meet the requirements for G A S/B as shown in Table 312300-1. RC-6 is not acceptable.

Table 312300-1

SIEVES		MASS PERCENT PASSING	
mm	Standard	BRG S/B	G A S/B
100	4 in.		
90	3 ½ in.		
63	2 ½ in.	100	
50	2 in.		100, \pm 3
37.5	1 ½ in.		90 - 100, \pm 5
25	1 in.	90 – 100	
19	¾ in.		

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Table 312300-1			
SIEVES		MASS PERCENT PASSING	
12.5	½ in.	60 - 100	
9.5	3/8 in.		
4.75	#4		30 - 60, ± 10
2.36	#8		
2.0	#10	35 - 90	
0.60	#30		
0.425	#40	20 - 55	
0.075	#200	5 - 25	0 - 12, ± 5

- F. Engineered Fill: Subbase or base materials
 - G. Bank Run Gravel for subbases: Bank Run Gravel for subbase courses shall meet the requirements for BRG S/B as shown in Table 312300-1.
 - H. Drainage Fill: Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel, ASTM D 448, coarse aggregate grading size 57, with 100 percent passing a 1 1/2 inch sieve and not more than 5 percent passing a No. 8 sieve.
 - I. Filtering Material: Evenly graded mixture of natural or crushed gravel or crushed stone and natural sand, with 100 percent passing a 1 1/2 inch sieve and 0 to 5 percent passing a No. 50 sieve.
 - J. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.
- 2.2 ACCESSORIES
- A. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick minimum, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep.
 - 1. Tape Colors: Provide tape colors to utilities as follows:
 - a. Red: Electric
 - b. Yellow: Gas, oil, steam, and dangerous materials
 - c. Orange: Telephone and other communications
 - d. Blue: Water Systems
 - e. Green: Sewer Systems

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

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- B. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.
- C. Provide erosion control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
- D. Tree protection is specified in the Division 311000 Section "Site Clearing".

3.2 DEWATERING

- A. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding project site and surrounding area.
- B. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
- C. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, and sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.
 - 1. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water to be removed from excavation to collecting or runoff areas. Do not use foundation or pipeline excavations as temporary drainage ditches.
- D. During Construction, the grading operations shall be performed in a manner such that the excavation will be well drained at all times. When necessary, excavations shall be drained to sumps, which shall be pumped continuously, if required, to an approved sediment control device. The Contractor shall maintain and keep all ditches open and free from soil and debris while in service or until final acceptance of the work, and all grading shall be done on neat, regular lines conforming to the sections and contours shown on the plans. All work done in proper sequence with all other associated operations. Before slab or surfacing is placed, all drainage facilities shall be installed which are required to permit free and uninterrupted flow of the surface and underground water from the site or to pumping sumps, etc.

3.3 EXCAVATION

- A. Explosives: Do not use explosives.
- B. Unclassified Excavation: Excavation is unclassified and includes excavation to required subgrade elevations regardless of the character of materials and obstructions encountered.
- C. All suitable materials removed in excavation shall be used in accordance with the provisions of the section except that topsoil may be required to be salvaged and stored as specified.
- D. If in the opinion of the Testing Agent undercutting is required, removal shall be made of slides, material. When slides or washout occur in either cut or fill, the damage shall be repaired by the Contractor at no additional cost to the Owner. If the material is to be removed from an embankment area, it will be necessary for the Testing Agent to have it measured for payment by means of additional preliminary and final cross sections or some other suitable method.

3.5 STABILITY OF EXCAVATIONS

- A. Comply with local codes, ordinances, and requirements of authorities having jurisdiction to maintain stable excavations.

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- B. Slope sides of excavation to comply with local codes, ordinances, and requirements of authorities having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated.
- C. Maintain sides and slopes of excavations in safe condition until completion of backfilling.
- D. Shoring and bracing: Provide materials for shoring and bracing, such as sheet piling, uprights, stringers, and cross braces in good serviceable condition. Maintain shoring and bracing in excavations regardless of time period excavations will be open. Extend shoring and bracing as excavation progresses.

3.6 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within tolerance of plus or minus 2 inches. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, installing services and other construction, and for inspection.
 - 1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
 - 2. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Appurtenances: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 2 inches. Do not disturb bottom of excavations intended for bearing surface.

3.7 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated cross sections, elevation and grades.

3.8 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated slopes, lines, depths, and invert elevations.
 - 1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
- B. Excavate trenches to uniform widths to provide a working clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe conduit, unless otherwise indicated.
 - 1. Clearance: 12 inches each side of pipe or conduit.
- C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels, of pipes and for joints, fittings, and bodies of conduits. Remove stones and sharp objects to avoid point loading.
 - 1. For pipes or conduit less than 6 inches in nominal diameter and flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
 - 2. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill. At each pipe joint, dig bell holes to relieve pipe bells of loads and ensure continuous bearing of pipe barrel on bearing surface.

3.9 UNAUTHORIZED EXCAVATION

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- A. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom, without altering required top elevation. Lean concrete fill may be used to bring elevations to proper position, when acceptable to Architect.
- B. In locations other than those above, backfill and compact unauthorized excavations as specified for authorized excavations of same classification, unless otherwise directed by the Architect.

3.10 APPROVAL OF SUBGRADE

- A. Notify the Testing Agent when excavations have reached required subgrade.
- B. When Testing Agent determines that unforeseen unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed by the Testing Agent.
 - 1. Unforeseen additional excavation and replacement material will be paid according to the Contract provisions for changes in Work.
- C. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by the Engineer.

3.11 STORAGE OF SOIL MATERIALS

- A. Stockpile excavated materials acceptable for backfill and fill soil materials, including acceptable borrow materials. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent wind-blown dust.
 - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.12 BACKFILL

- A. Backfill excavations promptly, but not before completing the following:
 - 1. Acceptance of construction below finish grade including, where applicable, damp proofing, waterproofing, and perimeter insulation.
 - 2. Surveying locations of underground utilities for record documents.
 - 3. Testing, inspecting, and approval of underground utilities.
 - 4. Concrete formwork removal.
 - 5. Removal of trash and debris from excavation.
 - 6. Removal of temporary shoring and bracing, and sheeting.
 - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

3.13 UTILITY TRENCH BACKFILL

- A. Place and compact bedding course on stable bearing surface and to fill unauthorized excavations. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- B. Concrete backfill trenches that carry below or pass under footings and that are excavated within 18 inches of footings. Place concrete to level of 4 inches above bottom of footings.

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- C. Provide 4-inch thick concrete base slab support for piping or conduit less than 30 inches below surface of roadways. After installation and testing, completely encase piping or conduit in a minimum 4 inches of concrete before backfilling or placing roadway subbase.
- D. Place and compact initial backfill of satisfactory soil material or subbase material, free of particles larger than 1 inch, to a height of 12 inches over the utility pipe or conduit.
 - 1. Carefully compact material under pipe haunches and bring backfill evenly up to both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.
- E. Coordinate backfilling with utilities testing.
- F. Fill voids with approved backfill materials as shoring and bracing, and sheeting is removed.
- G. Place and compact final backfill of satisfactory soil material to final subgrade.
- H. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.14 BUILDING SLAB DRAINAGE COURSE

- A. General: Drainage course consists of placement of drainage fill material, in layers of indicated thickness, over subgrade surface to support concrete building slabs.
- B. Placing: Place drainage fill material on prepared subgrade in layers of uniform thickness, conforming to indicated cross-section and thickness. Maintain optimum moisture content for compacting material during placement operations.
 - 1. Provide minimum 6 inches of drainage fill below all slabs. Drainage fill shall be an evenly graded mixture of natural or crushed gravel or crushed stone and natural sand with 100 percent passing a 2 inch sieve and less than 5 percent passing a No. 50 sieve. Place in a single layer and compact. Place in multiple layers if over 6 inches thick. Overlay fill with vapor barrier below all slabs.

3.15 SUBSURFACE DRAINAGE BACKFILL

- A. Subsurface Drain: Place a layer of filter fabric around perimeter of drainage trench or at footing, as indicated. Place a 6 inch compacted course of filtering material on filter fabric to support drainage pipe. After installing and testing, encase drainage pipe in a minimum of 6 inches of compacted filtering material and wrap in filter fabric, overlapping edges at least 6 inches.
- B. Impervious Fill: Place and compact impervious fill material for top 12" to final subgrade.

3.16 FILL

- A. Preparation: Remove vegetation, topsoil, debris, wet, and unsatisfactory soil materials, obstruction, and deleterious materials from ground surface prior to placing fills.
 - 1. Plow strip, or break up sloped surface steeper than 1 vertical 4 horizontal so fill material will bond with existing surface. Compact all surface with a minimum 10 ton smooth drum or sheepfoot roller.
- B. When subgrade or existing ground surface to receive fill has density less than required for fill, break up ground surface to depth required, pulverize, moisture-condition or aerate soil and recompact to required density.

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- C. Place fill material in layers to required elevations for each location listed below.
 - 1. Under grass, use satisfactory excavated or borrow soil material.
 - 2. Under walks and pavements, use subbase or base material, or satisfactory excavated or borrow soil material.
 - 3. Under steps and ramps, use subbase material.
 - 4. Under building slabs, use drainage fill material.
 - 5. Under piping and conduit and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation. Shape excavation bottom to fit bottom 90 degrees of cylinder.
- D. Note that high or low moisture contents do not render a soil as "unsuitable" as the contractor is wholly responsible for moisture conditioning of the soils (i.e., scarifying/loosening and wetting or drying). Undercuts will only be authorized if the soils remain unsuitable when the soil in question is at optimal moisture content.
- E. All suitable materials removed in excavation shall be used in accordance with the provisions of this section. It shall be the obligation of the Contractor to utilize all suitable materials from excavation in the construction of fills throughout the entire area of the Contract.

3.17 MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill layer before compaction to within 3 percent of optimum moisture content.
 - 1. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Remove and replace, or scarify and air-dry satisfactory soil material that is too wet to compact to specified density.
 - a. Stockpile or spread and dry removed wet satisfactory soil material.

3.18 COMPACTION

- A. Place backfill and fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill materials evenly on all sides of structures to required elevations to prevent wedging action. Place backfill and fill uniformly along the full length of each structure.
- C. Control soil and fill compaction, providing minimum percentage of density specified for each area classification indicated below. Correct improperly compacted areas or lifts as directed by Architect if soil density tests indicate inadequate compaction.
- D. Percentage of Maximum Dry Density Requirements: Compact soil to not less than the following percentages of maximum dry density according to AASHTO T-180:
 - 1. Under structures, building slabs, steps, and pavements, compact the materials below subgrade to 95 percent maximum dry density (AASHTO T-180), with a moisture content range of minus to plus 2 percent of optimum. Immediately prior to placement of slab stone base, recompact the subgrade to a firm unyielding condition and to at least 95% of the AASHTO T-180 maximum dry density.

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2. Under walkways, compact the materials below subgrade to 95 percent maximum dry density (AASHTO T-180), with a moisture content range of minus to plus 2 percent of optimum.
 3. Under lawn or unpaved areas, compact the materials below subgrade to 95 percent maximum dry density (AASHTO T-180), with a moisture content range of minus to plus 2 percent of optimum.
- E. Proofroll all areas which are to receive pavements and slab-on-grade for the proposed school building with vehicle having a minimum axle load of 20 tons. Unsuitable materials shall be removed and replaced with new compacted fill.
- F. When existing ground surface has a density less than that specified under "Compaction" for particular area classification, break up ground surface, pulverize, moisture-condition to optimum moisture content, and compact to required depth and percentage of maximum density.

3.19 GRADING

- A. General: Uniformly grade areas to a smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
1. Provide a smooth transition between existing adjacent grades and new grades.
 2. Cut out soft spots, fill low spots, and trim high spots to conform to required surface tolerances.
- B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
1. Lawn or Unpaved Areas: Plus or minus 2 inch.
 2. Walks: Plus or minus 2 inch.
 3. Pavements: Plus or minus 2 inch.
- C. Grading Inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10 foot straightedge.

3.20 SUBBASE AND BASE COURSES

- A. Under pavements and walks, place subbase course material on prepared subgrades. Place base course material over subbases to pavements.
1. Compact subbase course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of AASHTO T-180 maximum dry density.
 2. Shape subbase and base to required crown elevations and cross-slope grades.
 3. When thickness of compacted subbase or base course is 6 inches or less, place materials in a single layer.
 4. When thickness of compacted subbase or base course exceed 6 inches, place materials in equal layers, with no layer more than 6 inches thick or less than 3 inches thick when compacted.

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- B. Pavement Shoulders: Place shoulder along edges of subbase and base course to prevent lateral movement. Construct shoulders at least 12 inches wide of acceptable soil materials and compact simultaneously with each subbase and base layer.

3.21 DRAINAGE FILL

- A. Under slabs-on-grade, place drainage fill course on prepared subgrade.
1. Compact drainage fill to required cross sections and thickness,
 2. When compacted thickness of drainage fill is 6 inches or less, place materials in a single layer.
 3. When compacted thickness of drainage exceeds 6 inches thick place materials in equal layers, with no layer more than 6 inches thick nor less than 3 inches thick when compacted.

3.22 FIELD QUALITY CONTROL

- A. Testing Agency Service: Allow testing agency to inspect and test each subgrade and each fill or backfill layer. Do not proceed until test results for previously completed work verify compliance with requirements.
1. Perform field-in-place density tests according to ASTM D 1556 (sand cone method).
 - a. Field-in-place density tests may also be performed by the nuclear method according to ASTM D 6938, provided that calibration curves are periodically checked and adjusted to correlate to tests performed using ASTM D 1556. With each density calibration check, check the calibration curves furnished with the moisture gages according to ASTM D 3017.
 - b. When field-in-place density tests are performed using nuclear methods, make calibration checks of both density and moisture gages at beginning of work, on each difference type of material encountered, and at intervals as directed by the Engineer.
 2. Footing Subgrade: Inspect bearing state at each column footing and at twenty foot intervals in wall footings, at the footing subgrade, to verify required bearing capacity.
 3. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, perform at least one field in-place density test for every 2500 sq. ft. or less of paved areas or building slab, but in no case fewer than three tests.
 4. Foundation Wall Backfill: In each compacted backfill layer, perform at least one field in-place density test for each 100 feet or less of wall length, but no fewer than two tests along a wall face.
 5. Trench Backfill: In each compacted backfill layer, perform at least one field in-place density test for each 150 feet or less of trench, but no fewer than two tests.
- B. When testing agency reports that subgrades, fills, or backfills are below specified density, scarify and moisten or aerate, or remove and replace soil to the depth required, recompact and retest until required density is obtained. Retesting will be paid by the Contractor.

3.23 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

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- B. Repair and re-establish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace material to depth directed by the Architect; reshape and recompact at optimum moisture content to the required density.
- C. Settling: Where settling occurs during the Project correction period, remove finished surfacing, backfill with additional approved material, compact, and reconstruct surfacing.
 - 2. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.

3.24 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Transport surplus satisfactory soil and waste material, including unsatisfactory soil, trash, debris, and legally dispose of off the Owner's property.

END OF SECTION 312300

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SECTION 312500 - SOIL EROSION AND SEDIMENT CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Sediment and Stormwater Administration, Maryland Department of the Environment, Stormwater Management and Erosion and Sediment Control Guidelines for State and Federal Projects dated, Feb. 2015, and addenda thereto.
- C. Charles County Government Department of Planning and Growth Management Specifications and details dated July, 1995, revised December 1999 and as amended.
- D. Maryland Department of Transportation State Highway Administration Standard Specifications for Construction and Materials, dated January, 2008 and as amended.

1.2 SUMMARY

- A. The extent of soil erosion and sediment control facilities is shown on the Erosion and Sediment Control Plans, approved by the Charles Soil Conservation District.
- B. The contractor will assume responsibility for the erosion and sediment controls that currently exist on the site at the time the contract is executed, and will be responsible for the conversion of the erosion and sediment controls from their existing state to those outlined in the construction documents. Additionally, the contractor will also be responsible for all erosion and sediment controls outlined within the contract documents and/or any additional erosion and sediment controls required by the inspector at no additional cost to the Owner.

1.3 QUALITY ASSURANCE

- A. Comply with local codes where applicable and to the requirements of all permits.
- B. Comply with the provisions outlined in Division 1.

PART 2 - PRODUCTS

2.1 MATERIALS REQUIREMENTS

- A. Material requirements are specified on the drawings.

PART 3 - EXECUTION

3.1 GENERAL

- A. Installation of the soil erosion and sediment control facilities shall be as shown and specified on the Sediment/Erosion Control Plans and Detail sheets of the Contract Drawings.

3.2 TIMING

- A. All perimeter control shall be installed and approved by the Sediment Control Inspector as specified in the "Sequence of Construction" on the Contract Drawings.

3.3 MAINTENANCE

- A. All soil erosion and sediment control measures shall be maintained continuously during the

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construction period.

- B. Soil erosion and sediment control measures shall be inspected daily, and any measure which has been disturbed or damaged shall be repaired and restored to operating condition in accordance with the approved plan before the end of each work day at no additional cost to the Owner.

3.4 REMOVAL

- A. Soil erosion and sediment control measures shall not be removed until the removal has been authorized by the Sediment Control Inspector.

END OF SECTION 312500

SECTION 314000 – SHORING AND UNDERPINNING

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Design of bracing, shoring, and underpinning.
2. Selection of construction sequence.
3. Temporary bracing of the structure or portions of the structure as required to prevent the structure from becoming unsafe during construction.
4. Temporary shoring of portions of the structure as required to prevent the structure from becoming unsafe during construction.
5. Temporary shoring of excavations.
6. Construction and removal of posts, timbers, lagging, braces, etc. required in connection with bracing, shoring, and underpinning the structure during construction.
7. Excavation, concrete placement and backfilling required in connection with underpinning foundations.

C. Related Sections:

1. Division 03 Section "Cast-in-Place Concrete."

1.2 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.

1.3 DESIGN REQUIREMENTS

A. General: The stability and integrity of the structure during construction shall be maintained at levels generally acceptable within the construction industry by the use of bracing, shoring, and underpinning. In no case shall the structure be allowed to become unsafe during construction as defined by the local governing jurisdiction. Design stresses in bracing, shoring, and underpinning shall not exceed the allowable stresses in Section 51-1.06A (2) of the Standard Specifications.

B. Bracing and Shoring for Structures:

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1. The bracing and shoring systems required to provide temporary support of a structure or portions of a structure during construction shall be designed to support the dead, live, soil, earthquake and wind loads that may be imposed on the structure during construction in accordance with industry standards and generally accepted engineering principles.
 2. The proposed bracing and shoring systems shall have foundations designed for allowable soil bearing pressures in accordance with the geotechnical investigation prepared for the Project.
- C. Shoring of Excavations and Underpinning: The proposed shoring and underpinning systems shall be designed for earth pressures and allowable soil bearing values as applicable in accordance with the geotechnical investigation prepared for the Project.

1.4 SUBMITTALS

- A. Submit under provisions of Division 01 Section "General Requirements."
- B. Shop Drawings indicating layout, member sizes, connection details and construction sequence for bracing, shoring and underpinning. No work related to bracing, shoring or underpinning shall take place until the University has reviewed the Shop Drawings.
- C. Design calculations of bracing, shoring and underpinning showing member stresses and connections due to imposed loads.

1.5 QUALITY ASSURANCE

- A. Design calculations and Shop Drawings of proposed bracing, shoring, and underpinning of the structure shall be prepared, stamped, and signed by a Structural Engineer registered in the State of Maryland.

1.6 PROJECT CONDITIONS

1.7 WARRANTY

PART 2 - PRODUCTS

2.1 MATERIALS FOR SHORING AND BRACING

- A. Materials for shoring and bracing shall be undamaged, high quality materials.

2.2 CONCRETE FOR UNDERPINNING

- A. Concrete for underpinning shall meet the requirements of Division 03 Section "Cast-in-Place Concrete".

PART 3 - EXECUTION

3.1 CONSTRUCTION

- A. Construction of bracing, shoring and underpinning shall be in accordance with the reviewed Shop Drawings prepared by the Subcontractor's Engineer.

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- B. The Subcontractor shall hire the Engineer responsible for the design of bracing, shoring and underpinning and inspection of the work as detailed on the bracing, shoring, and underpinning Shop Drawings, prior to sawcutting or removing portions of the structure.
 - C. Excavations for underpinning the foundations shall be inspected by the Geotechnical Engineer prior to placement of concrete.
 - D. The Engineer responsible for design of bracing, shoring, and underpinning shall write a letter certifying that construction of bracing, shoring, and underpinning was completed in accordance with the bracing, shoring, and underpinning Shop Drawings and meets its approval, prior to placement of concrete, sawcutting, and removal or modification of portions of the structure.
 - E. Remove surplus excavated materials from site.
- 3.2 REMOVAL OF BRACING AND SHORING
- A. Bracing and shoring shall not be removed until the new members have acquired sufficient strength to support their weight and the loads superimposed thereon safely. In no case may bracing or shoring be removed until the time and sequence has been approved by the Engineer responsible for bracing and shoring and reviewed by the Architect.
 - B. In general, bracing and shoring of concrete shall remain in place for at least ten days, when they may be removed provided the concrete is sufficiently hard and will not be injured.

END OF SECTION 314000

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SECTION 321300 - RIGID PAVING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Charles County Government Department of Planning and Growth Management Specifications and details dated July, 1995, revised December 1999 and as amended.
- C. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Architect for consideration. Those judged to be equal to that specified will receive written approval.

1.2 SUMMARY

- A. This Section includes exterior Portland cement concrete paving for the following:
 - 1. Curbs and gutters.
 - 2. Walkways.
- B. Related Sections:
 - 1. Section 312300: Excavating, Filling & Grading
 - 2. Section 033000: Cast-in-Place Concrete

1.3 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specifications Sections.
- B. Product data for proprietary materials and items, including reinforcement and forming accessories, admixtures, joint systems, curing compounds, dry-shake finish materials, and others if requested by Architect.
- C. Design mixes for each class of concrete. Include revised mix proportions when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.
- D. Laboratory test reports for evaluation of concrete materials and mix design tests.
- E. Material certificates in lieu of material laboratory test reports when permitted by Architect. Material certificate shall be assigned by manufacturer and Contractor certifying that each material item complies with or exceed requirements. Provide certification from admixture manufacturers that chloride content complies with requirements.

1.4 QUALITY ASSURANCE

- A. Concrete Standards: Comply with provisions of the following standards, except where more stringent requirements are indicated.
 - 1. American Concrete Institute (ACI) 301, "Specifications for Structural Concrete for

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- Buildings."
2. ACI 318, "Building Code Requirements for Reinforced Concrete."
 3. Concrete Reinforcing Steel Institute (CRSI) "Manual of Standard Practice."
- B. Concrete Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
- C. Concrete Testing Service: The Owner will engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixes.
1. The contractor shall provide the Testing Agency a minimum of 24 hours notice prior to the performance of such testing required.
- D. In the event of a discrepancy between the Project Specifications, Construction Documents, Charles County Standard Specifications and Details, or other guidelines set forth by the authorities having jurisdiction the more stringent will apply.
- E. Contractor shall provide an on grade mockup of each color of integrally colored concrete paving indicated in the Architectural (AS) drawing sheets, including the regular non-color added concrete to verify selections made under sample submittals and to demonstrate finish. Sample slabs of each color are to be 60 inches x 60 inches and located immediately adjacent to each other for final approval by the Architect.

1.5 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 PRODUCTS

2.1 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other acceptable panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.
- B. Form Release Agent: Provide commercial formulation form release agent with a maximum of 350 fL volatile organic compounds (VOCs) that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

2.2 REINFORCING MATERIALS

- A. Reinforcing Bars and Tie Bars: ASTM A 615, Grade 60, deformed.
- B. Welded Steel Wire Fabric: ASTM A 185.
1. Furnish in flat sheets, not rolls, unless otherwise acceptable to Architect.
- C. Joint Dowel Bars: Plain steel bars, ASTM A 615, Grade 60. Cut bars true to length with end square and free of burrs.
- D. Hook Bolts: ASTM A 307, Grade A bolts, internally and externally threaded. Design hook bolt joint assembly to hold coupling against pavement form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.
- E. Supports for Reinforcement: Chairs, spacers, dowel bar supports, and other devices for

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spacing, supporting, and fastening reinforcing bars, welded wire fabric, and dowels in place. Use wire bar-type supports complying with CRSI specifications.

1. Use supports with sand plates or horizontal runners where base material will not support chair legs.

2.3 CONCRETE MATERIALS

A. Portland Cement: ASTM C 150, Type I.

1. Use one brand of cement throughout project unless otherwise acceptable to Architect.
2. Mix shall be in accordance with the Portland Association publication #IS174.02T "Concrete for Small Jobs".
3. All concrete shall be 3000 psi (MDSHA mix no.2), air-entrained (5% \pm 1%) and the proportions by volume shall be in accordance with Table 321300-1.
4. Contractor shall furnish to the Owner delivery tickets for the concrete at the time of delivery.

**TABLE 321300-1
PROPORTIONS BY VOLUME**

Maximum Size Coarse Aggregate	Cement	Sand	Aggregate	Water
3/8"	1	2 1/4"	1 1/2"	1/2"
1/2"	1	2 1/4"	2	1/2"
3/4"	1	2 1/4"	2 1/2"	1/2"
1"	1	2 1/4"	2 3/4"	1/2"
1 1/2"	1	2 1/4"	3	1/2"

B. Normal-Weight Aggregates: ASTM C 33, Class 4, and as follows: Provide aggregates from a single source.

1. Maximum Aggregate Size: 1 1/2 inches
2. Do not use fine or coarse aggregates that contain substances that cause spalling.
3. Local aggregates not complying with ASTM C33 that have been shown to produce concrete of adequate strength and durability by special tests or actual service may be used when acceptable to Architect.

C. Water: Potable.

D. Fiber Reinforcement: Synthetic fibers engineered and designed for secondary reinforcement of concrete slabs, complying with ASTM C 1116, Type III.

2.4 ADMIXTURES

A. Provide concrete admixtures that contain not more than 0.1 percent chloride ions.

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- B. Air-Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with other required admixtures.
- C. Water-Reducing Admixture: ASTM C 494, Type A.
- D. Products: Subject to compliance with requirements, provide one of the following:
 - 1. Air-Entraining Admixture:
 - a. Air-Tite or Amex 210; Cormix Construction Chemicals.
 - b. Air-Mix or Perma-Air; Euclid Chemical Co.
 - c. Darex AEA or Daravair; W.R. Grace & Co.
 - d. MB-VR or Micro-Air, Master Builders, Inc.
 - e. Sealtight AEA; W.R. Meadows, Inc.
 - f. Sika AER; Sika Corp.
 - 2. Water-Reducing Admixture:
 - a. Chemtard; ChemMasters Corp.
 - b. Type A Services; Cormix Construction Chemicals
 - c. Eucon WR-75; Euclid Chemical Co.
 - d. WRDA; W.R. Grace & Co.
 - e. Pozzolith Normal or Polyheed; Master Builders, Inc.
 - f. Metco W.R.; Metalcrete Industries
 - g. Plastocrete 161; Sika Corp.

2.5 CURING MATERIALS

- A. Moisture-Retaining Cover: polyethylene sheet material shall have finished product weight of not less than 10 oz. per square yard.
- B. Liquid Membrane-Forming Curing Compound: AASHTO M-148.
- C. Products: Subject to compliance with requirements, provide one of the following:
 - 1. Liquid Membrane-Forming Curing Compound:
 - a. Clear Cure; Anti-Hydro Co., Inc.
 - b. Spartan-Cote; The Burke Co.
 - c. All Resin; Conspec Marketing & Mfg. Co.
 - d. Sealco 309; Cormix Construction Chemicals
 - e. Day-Chem Cure and Seal; Dayton Superior Corp.

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- f. Diamond Clear; Euclid Chemical Corp.
- g. #64 Resin Cure-Clear; Lambert Corp.
- h. L&M Cure R; L&M Construction Chemicals
- i. Masterkure; Master Builders, Inc.
- j. 3100 Series; W.R. Meadows, Inc.
- k. Seal N Kure; Metalcare Industries
- l. Kure-N-Seal; Sonneborn-Chemrex
- m. Horn Clear Seal; Tamms/A.C. Horn

2.6 RELATED MATERIALS

- A. Boiled Linseed Oil Mixture: Combination of boiled linseed oil and mineral spirits, complying with AASHTO.
- B. Bonding Agent: Acrylic or styrene butadiene.
- C. Epoxy Adhesive: ASTM C 881, two-component material suitable for dry or damp surfaces. Provide material type, grade, and class to suit requirements.
- D. Products: Subject to compliance with requirements, provide one of the following:
 - 1. Dry-Shake Color Hardener
 - 2. Bonding Agent
 - a. Acrylic Bondcrete; the Burke Co.
 - b. Strongbond; Conspec Marketing and Mfg. Co.
 - c. Day-Chem Ad Bond (J-40); Dayton Superior Corp.
 - d. SBR Latex; Euclid Chemical Co.
 - e. Daraweld C; W.R. Grace & Co.
 - f. Everbond; L&M Construction Chemicals, Inc.
 - g. Acryl-Set; Master Builders, Inc.
 - h. Intralok; W.R Meadows, Inc.
 - i. Acrylpave; Metalcare Industries
 - j. Sonocrete, Sonneborn-Chemrex
 - k. Stonlok LB2; Stonhard, Inc.
 - l. Strong Bond; Symons Corp.
 - 3. Epoxy Adhesive:

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- a. Burke Epoxy M.V.; the Burke Co.
- b. Spec-Bond 100; Conspec Marketing and Mfg. Co.
- c. Resi-Bond (J-58); Dayton Superior
- d. Euco-Epoxy System #452 or #620; Euclid Chemical Co.
- e. Concresive Standard Liquid; Master Builders, Inc.
- f. Rezi-Weld 1000; W.R. Meadows, Inc.
- g. Metco Hi-Mod Epoxy; Metalcrete Industries
- h. Sikadur 32 Hi-Mod; Sika Corp.
- i. R-6000 Series; Symons Corp.
- j. Epoxite Binder 2390; Tamms/A.C. Horn, Inc.

2.7 CONCRETE MIX

- A. Prepare design mixes for each type and strength of normal-weight concrete by either laboratory trial batch or field experience methods as specified in ACI 301. For the trail batch method, use a qualified independent testing agency for preparing and reporting proposed mix designs.
 - 1. Do not use the Owner's field quality-control testing agency as the independent testing agency.
- B. Proportion mixes according to ACI 211.1 and ACI 301 to provide normal-weight concrete with the following properties:
 - 1. Compressive Strength (28-Day): 3000 psi
 - 2. Maximum Water-Cement Ratio at Point of Placement: 0.45
 - 3. Slump Limit at Point of Placement: 4 inches.
- C. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content as follows with a tolerance of plus or minus 12 percent.
 - 1. Air Content: 5.5 percent for 12-inch maximum aggregate.
- D. Fiber Reinforcement: Add to mix at a rate of 1/5 lb per cu. yd., unless manufacturer recommends otherwise.
- E. Adjustment to Concrete Mixes: Mix design adjustments may be requested by Contractor when characteristics of materials, project condition, weather, test results, or other circumstances warrant.

2.8 CONCRETE MIXING

- A. Ready-Mixed Concrete: Comply with requirements and with ASTM C 94.
 - 1. When air temperature is between 85 deg F and 90 deg F, reduce mixing and delivery time from 1 1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

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2.9 JOINT MATERIALS

- A. Vinylex waterstop cap strip control joint manufactured by Vinylex or approved equal.
- B. Performed Joint Fillers
 1. The bituminous fiber type shall be in accordance with AASHTO M213 with the bituminous content determined by AASHTO T164.
 2. The weathering test shall be deleted for either type of material.
- C. Roofing paper to be used in construction joints shall be composed of roofing felt saturated and coated on both sides with an asphaltic material. It shall not weigh less than 39.8 lbs/100 square foot and shall not crack when bent over 2 inch radius at room temperature.

2.10 JOINT SEALANTS

- A. Compatibility: Sealant fillers and all adjacent materials shall be compatible as demonstrated by sealant manufacturer testing.
- B. Colors - Provide color of exposed joint sealants to comply with the following:
 1. Match colors of concrete.
- C. Cold Applied Joint Sealants shall be one part, polyurethane-base sealant for concrete pourable, chemically curing elastomeric formulation complying with the following requirements relative to formulation with ASTM C 920 for Type s, Grade NS, Class 25, and Uses indicated.

2.11 JOINT SEALANT BACKING

- A. General: Provide sealant backings of material and type that are nonstaining; are compatible with joint substrates; sealants, primers, and other joint fillers, and are approved for applications indicated by sealants manufacturer based on field experience and laboratory testing.
- B. Backer Rods for Cold Applied Sealants: Performed, compressible, resilient, nonwaxing, nonextruding strips of flexible, plastic foam of material indicated below and of size, shape, and density to control sealant depth and otherwise contribute to producing optimum sealant performance.
 1. Closed cell polyethylene foam, nonabsorbent to liquid water and gas, and nonoutgassing in unruptured state.
 2. Proprietary, reticulated, closed-cell polymeric foam, nonoutgassing, with a density of 2.5pcf and tensile strength of 35 psi per ASTM D 1623, and with water absorption less than 0.02 gram/cubic centimeter per ASTM C 1083.
 3. Either material indicated above.
- C. Bond Breaker Type: Polyethylene tape or other plastic tape as recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint filler materials or joint surfaces at back of joint where such adhesions would result in sealant failure. Provide self-adhesive tape where applicable.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

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- A. Proof-roll prepared subbase surface to check for unstable areas and verify need for additional compaction. Do not begin paving work until such conditions have been corrected and are ready to receive paving.
- B. Remove loose material from compacted subbase immediately before placing concrete.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for paving to required lines, grades, and elevations. Install forms to allow continuous progress of work and so that forms can remain in place at least 24 hours after concrete placement
- B. Check completed formwork and screeds for grade and alignment to following tolerances:
 1. Top of Forms: Not more than $\frac{1}{2}$ inch in 10 feet.
 2. Vertical Face on Longitudinal Axis: Not more than $\frac{1}{2}$ inch in 10 feet.
- C. Clean forms after each use and coat with form release agent as required to ensure separation from concrete without damage.

3.3 PLACING REINFORCEMENT

- A. General: Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars" for placing and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain maximum cover to reinforcement.
- D. Install welded wire fabric in lengths as long as practicable. Lap adjoining pieces at least one full mesh and laces splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

3.4 JOINTS

- A. General: Construct contraction, construction, and isolation joints true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to the centerline, unless indicated otherwise.
- B. Contraction joints: Provide weakened-plane contraction joints, sectioning concrete into areas as shown on Drawings. Construct contraction joints for a depth equal to at least 1/4 of the concrete thickness, as follows:
 1. Tooled Joints: Form contraction joints in fresh concrete by grooving and finishing each edge of joint with a radiused jointer tool.
 2. Inserts: Form contraction joints by inserting premolded plastic, hardboard, or fiberboard strips into fresh concrete until top surface of strip is flush with paving surface. Radius each joint edge with a jointer tool. Carefully remove strips or caps of two-piece assemblies after concrete has hardened. Clean groove of loose debris.
- C. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than $\frac{1}{2}$ hour, unless paving terminates at isolation joints.

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1. Provide preformed galvanized steel or plastic keyway-section forms or bulkhead forms with key, unless indicated otherwise. Embed keys at least 1 ½ inches into concrete.
 2. Continue reinforcement across construction joints unless indicated otherwise. Do not continue reinforcement through sides of strip paving unless indicated.
 3. Provide tie bars at sides of paving strips where indicated.
 4. Use bonding agent one existing concrete surfaces that will be joined with fresh concrete.
- D. Isolation Joints: Form isolation joints of preformed joint filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
1. Locate expansion joints at intervals of 25 feet for sidewalks and 40 feet for curb and gutter, unless indicated otherwise.
 2. Extend joint filler full width and depth of joint, not less than ½ inch or more than 1 inch below finished surface where joint sealant is indicated. Place top of joint filler flush with finished concrete surface when no joint sealant is required.
 3. Furnish joint filler in one-piece lengths for full width being placed wherever possible. Where more than one length is required, lace or clip joint filler sections together.
 4. Protect top edge of joint filler during concrete placement with a metal, plastic, or other temporary preformed cap. Remove protection cap after concrete has been placed on both sides of joint.
- E. Walks shall be constructed to match existing concrete.
1. Expansion joints between building and pavement shall be bituminous fiber type.
 2. Expansion joints shall be installed between existing concrete pavement and new pavement.
 3. Pavements shall be separated from curbs by a construction joint using felt roofing paper material.
 4. "Vinylex Waterstop Cap Strip" control joint to be installed at a maximum of 25' and between existing walks and new concrete.
 5. Saw cut control joints are not permitted.
 6. Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt-coat one half of dowel length to prevent concrete bonding to one side of joint.

3.5 JOINT SEALANT INSTALLATION

- A. Clean out joints before installing joint sealants to comply with recommendations of manufacturer.
- B. Comply with Joint Manufacturer printing installation instructions and recommendations of ASTM C 962 for use of joint sealants.
- C. Immediately after sealant application and prior to time skinning or curing begins, tool sealants to a smooth, uniform bead to eliminate air pockets and to ensure contact and adhesion of sealant with sides of joint.
1. Do not use tooling agent that discolor sealants or adjacent surface or are not approved by

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the sealant manufacturer.

2. Protect joint sealants during and after curing period from contact with contaminating substances or from damage resulting from construction operations or other causes so they are without deterioration at final acceptance.

3.6 CONCRETE PLACEMENT

- A. Inspection: Before placing concrete, inspect and complete framework installation, reinforcing steel, and item to be embedded or cast in. Notify other trades to permit installation of their work.
- B. Remove ice, snow, or frost from subbase surface and reinforcing before placing concrete. Do not place concrete on surfaces that are frozen.
- C. Moisten subbase to provide a uniform dampened condition at the time concrete is placed. Do not place concrete around manholes or other structures until they are at the required finish elevation and alignment.
- D. Comply with requirements with ACI 304R for measuring, mixing, transporting, and placing concrete.
- E. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
 1. When concrete placing is interrupted for more than $\frac{1}{2}$ hour, place a construction joint.
- F. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- G. Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures to consolidate concrete complying with ACI 309R.
 1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand-spreading and consolidation. Consolidate with care to prevent dislocating reinforcing, dowels, and joint devices.
- H. Screeed paved surfaces with a straightedge and strike off. Use bull floats or darbies to form a smooth surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces prior to beginning finishing operations.
- I. Place concrete in two operations; strike off initial pour for entire width of placement and to the required finish surface. Lay welded wire fabric or fabricated bar mats immediately in final position. Place top layer of concrete, strike off, and screed.
 1. Remove and replace portions of bottom layer of concrete that have been placed more than 15 minutes without being covered by top layer or use bonding agency if acceptable to Architect.
- J. Curbs and Gutters: When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs and gutter to required cross section, lines, grade, finish and jointing as specified for formed concrete. If results are not acceptable, remove and replace with formed concrete.
- K. Slip Form Pavers: When automatic machine placement is used for paving, submit revised mix

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design and laboratory test results that meet or exceed requirements. Produce paving to required thickness, lines, grades, finish, and jointing as required for formed paving.

1. Compact subbase and prepared subgrade of sufficient width to prevent displacement of pave machine during operation.
- L. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.
- M. Cold Weather Placement: Comply with provision of ACI 306R and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 1. When air temperature has fallen to or is expected to fall below 40°F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50° F and not more than 80° F at point of placement.
 2. Do not use frozen materials or materials containing ice or snow.
 3. Do not use calcium chloride, salt, or other materials containing antifreeze agent or chemical accelerators unless otherwise accepted in mix designs.
- N. Hot Weather Placement: Place concrete complying with ACI 305R and as specified when hot weather conditions exist.
 1. Cool ingredients before mixing to maintain concrete temperature at time of placement to below 90° F. Mixing water may be chilled or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to concrete is Contractor's option.
 2. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedding in concrete.
 3. Fog spray forms, reinforcing steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spot, or dry areas.

3.7 CONCRETE FINISHING

- A. Float Finish: Begin floating when bleed water sheen has disappeared and the concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand-floating if area is small or inaccessible to power units. Finish surfaces to true planes within a tolerance of $\frac{1}{4}$ inch in 10 feet as determined by a 10-foot-long straightedge placed anywhere on the surface in any direction. Cut down high spots and fill low spots. Refloat surface immediately to a uniform granular texture.
 1. Burlap Finish: Drag a seamless strip of damp burlap across concrete, perpendicular to line of traffic, to provide a uniform gritty texture finish.
 2. Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across concrete surface perpendicular to line of traffic to provide a uniform fine line texture finish.
- B. Final Tooling: Tool edges of paving, gutter, curbs, and joints formed in fresh concrete with a jointing tool to the following radius. Repeat tooling of edges and joints after applying surface finishes. Eliminate tool marks on concrete surfaces.
 1. Radius: 3/8 inch

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3.8 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with the recommendations of ACI 306R for cold weather protection and ACI 305R for hot weather protection during curing.
- B. Evaporation Control: In hot, dry, and windy weather, protect concrete from rapid moisture loss before and during finishing operations with an evaporation-control material. Apply according to manufacturer's instruction after screeding and bull floating, but before floating.
- C. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- D. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:
 1. Moisture-Curing: Keep surfaces continuously moist for not less than 7 days with the following materials:
 - a. Water.
 - b. Continuous water-fog spray.
 - c. Absorptive cover, water saturated, and keep continuously wet. Cover concrete surfaces and edges with a 12-inch lap over adjacent absorptive covers.
 2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
 3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.
- E. Boiled Linseed Oil treatment: Apply linseed oil mixture no sooner than 28 days after placement to clean dry concrete surfaces free of oil, dirt, or other foreign material. Apply on 2 sprayed applications at rate of 40 sq. yd. per gallon for the first application and 60 sq. yd. per gallon for the second application. Allow complete drying between applications.

3.9 FIELD QUALITY CONTROL TESTING

- A. The Owner will employ a qualified testing and inspection agency to sample materials, perform tests, and submit test reports during concrete placement. Sampling and testing for quality control may include the following:
 1. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
 - a. Slump: ASTM C 143; one test at point of placement for each compressive-strength test but no less than one test for each day's pour of each type of concrete. Additional tests will be required when concrete consistency changes.
 - b. Air Content: ASTM C 231, pressure method; one test for each compressive-strength test but no less than one test for each day's pour of each type of air-entrained concrete.

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- c. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40° F and below and when 80° F and above, and one test for each set of compressive-strength specimens.
 - d. Compression Test Specimens: ASTM C 31; one set of four standard cylinders for each compressive-strength test, unless directed otherwise. Mold and store cylinders for laboratory-cured test specimens except when field-cured test specimens are required.
 - e. Compressive-Strength Tests: ASTM C 39; one set for each day's pour of each concrete class exceeding 5 cu. yd. But less than 25 cu. yd., plus one set for each additional 50 cu. yd. Test one specimen at 7 days, test two specimens at 28 days, and retain one specimen in reserve for later testing if required.
- 2. When frequency of testing will provide fewer than five strength tests for a given class of concrete, conduct testing from at least five randomly selected batches or from each batch if fewer than five are used.
 - 3. When total quantity of a given class of concrete is less than 50 cu. yd., Architect may waive strength testing if adequate evidence of satisfactory strength is provided.
 - 4. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operation and provide corrective procedures for protecting and curing the in-place concrete.
 - 5. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength and no individual strength test results falls below specified compressive strength by more than 500 psi.
- B. Test results will be reported in writing to Architect, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive strength tests shall contain the Project identification name and number, date of concrete placement, name of concrete testing agency, concrete type and class, location of concrete batch in paving, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-day and 28-day tests.
 - C. Nondestructive Testing: Impact hammer sonoscope, or other nondestructive device may be permitted but shall not be used as the sole basis for acceptance or rejection.
 - D. Additional Tests: The testing agency will make additional tests of the concrete when test results indicate slump, air entrainment, concrete strengths, or other requirements have not been met, as directed by Architect. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.
- 3.10 REPAIRS AND PROTECTION
- A. Remove and replace concrete paving that is broken, damaged, or defective, or does not meet the requirements of this Section.
 - B. Drill test cores where directed by Architect when necessary, to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with Portland cement concrete bonded to paving with epoxy adhesive.
 - C. Protect concrete from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

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- D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep concrete paving not more than 2 days prior to date scheduled for Substantial Completion inspections.

END OF SECTION 321300

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SECTION 323100 - CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Charles County Government Department of Planning and Growth Management Specifications and details dated July, 1995, revised December 1999 and as amended.
- C. Maryland Department of Transportation State Highway Administration Standard Specifications for Construction and Materials, dated January, 2008 and as amended.

1.2 DESCRIPTION

- A. This Section includes the following:
 - 1. Aluminized-steel chain link fabric.
 - 2. Aluminized-steel framework.

1.3 RELATED SECTIONS

- A. Section 033000: Cast-In-Place Concrete
- B. Section 312300: Excavating and Filling

1.4 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data in the form of manufacturer's technical data, specifications, and installation instructions for fence and gate posts, fabric, gates, gate operators, and accessories.
- C. Shop drawings showing location of fence, gates, each post, and details of post installation, extension arms, gate swing, hardware, and accessories.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced Installer who has at least three years' experience and has completed at least five chain link fence projects with same material and of similar scope to that indicated for this Project with a successful construction record of in-service performance.
- B. Single-Source Responsibility: Obtain chain link fences and gates, including accessories, fittings, and fastenings, from a single source.
- C. In the event of a discrepancy between the Project Specifications, Construction Documents, Charles County Standard Specifications and Details, or other guidelines set forth by the authorities having jurisdiction the more stringent will apply.

1.6 PROJECT CONDITIONS

- A. Field Measurements: Verify layout information for fences and gates shown on the Drawings in

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relation to the property survey and existing structures. Verify dimensions by field measurements.

PART 2 - PRODUCTS

2.1 FABRIC

- A. Selvage: Knuckled on both selvages.
- B. Steel Chain-Link Fence Fabric: Fabricated in one-piece widths for fencing 12 feet and less in height to comply with Chain Link Fence Manufacturers Institute (CLFMI) "Product Manual" and with requirements indicated below:
 - 1. Mesh and Wire Size: 1-inch mesh, 0.148-inch diameter (9 gage) unless otherwise noted on the plans.
 - 2. Coating: ASTM A 817, Type 2, Class 1, zinc-coated (Aluminized) applied after weaving.

2.2 FRAMING

- A. Round member sizes are given in actual outside diameter (OD) to the nearest thousandth of inches. Round fence posts and rails are often referred to in ASTM standard specifications by nominal pipe sizes (NPS) or the equivalent trade sizes in inches. The following indicates these equivalents all measured in inches:

<u>Actual OD</u>	<u>NPS Size</u>	<u>Trade Size</u>
1.315	1	1-3/8
1.660	1-3/8	1-5/8
1.900	1-1/2	2
2.375	2	2-1/2
2.875	2-1/2	3
3.500	3	3-1/2
4.000	3-1/2	4
6.625	6	6-5/8
8.625	8	8-5/8

- B. Type I Round Posts: Standard weight (schedule 40) Aluminized-steel pipe conforming to ASTM F 1083, according to heavy industrial requirements of ASTM F 669, Group IA, with minimum yield strength of 25,000 psi, not less than 1.8 oz. of zinc per sq. ft. Type A coating inside and outside according to ASTM F 1234, as determined by ASTM A 90, and weights per foot as follows:

<u>Actual OD</u>	<u>Weight (lb/ft)</u>	<u>NPS Size</u>
1.315	1.68	1
1.660	2.27	1-1/4
1.900	2.72	1-1/2
2.375	3.65	2
2.875	5.79	2-1/2
3.500	7.58	3
4.000	9.11	3-1/2
6.625	8.97	6
8.625	28.55	8

- C. Type II Round Posts: Cold-formed, electric-welded steel pipe conforming to heavy industrial

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requirements of ASTM F 669, Group IC, with minimum yield strength of 50,000 psi, either protective coating system below according to ASTM F 1234, and weights per foot as follows:

1. Coatings: Type B outside with a minimum of 0.9 oz. of zinc per sq. ft. after welding, a chromate conversion coating and a clear polymer overcoat. Type B inside with a minimum of 0.9 oz. of zinc per sq. ft. or Type D inside with a minimum 0.3-mil-thick, 81-percent zinc-pigmented nominal coating.
2. Coatings: Type C inside and outside with not less than 0.9 oz. of zinc-5 percent aluminum-mischmetal alloy per sq. ft.

<u>Actual OD</u>	<u>Weight (lb/ft)</u>	<u>NPS Size</u>
1.315	1.35	1
1.660	1.84	1-1/4
1.900	2.28	1-1/2
2.375	3.12	2
2.875	4.64	2-1/2
3.500	5.71	3
4.000	6.56	3-1/2

- D. Roll-Formed Steel: Rolled form steel shapes (e.g., C section) produced from structural-quality steel conforming to ASTM A 570, grade 45, or ASTM A 446, grade D, Aluminized, conforming to heavy industrial requirements of ASTM F 669, Group II, with a minimum yield strength of 45,000 psi. Protective coating system according to ASTM F 1234, Type A, hot-dip Aluminized with a minimum of 2.0 oz. of zinc per sq. ft. according to ASTM A 123, 4.0 oz. of zinc per sq. ft. according to ASTM A 525; or Type C, a minimum of 1.0 oz. of zinc-5 percent aluminum-mischmetal alloy per sq. ft. according to ASTM A 875.
- E. Roll-Formed Steel: Hot-rolled steel shape H section with a minimum yield strength of 45,000 psi conforming to ASTM F 669, group III. Protective coating system according to ASTM F 1234, Type A, hot-dip Aluminized with a minimum of 2.0 oz. of zinc per sq. ft. of according to ASTM A 123, or 4.0 oz. of zinc per sq. ft. according to ASTM A 525.
- F. Top Rails: Manufacturer's longest lengths (17 to 21 feet) with swaged-end or expansion-type coupling, approximately 6 inches long for joining. Provide rail ends or other means for attaching top rail securely to each gate corner, pull, and end post.
1. Roll-Formed Steel: 1.660 inch OD SS40 steel pipe, weighing 1.83 lbs/lf.
- G. Steel Posts:
1. Roll-Formed Line Posts: 2.5-inch OD SS40 hot-Aluminized, steel pipe, weighing 3.17 lbs/lf.
 2. Roll-Formed End, and Corner Posts: 3.0-inch OD SS40 hot-Aluminized, steel pipe, weighing 4.64 lbs/lf.
- H. Swing Gate Posts: Furnish posts to support single gate leaf, or one leaf of a double-gate installation, according to ASTM F 900, sized as follows for steel pipe posts:
1. Steel posts:
 - a. Up to and Including 6 Feet: 2.875-inch OD pipe weighing at least 5.79 lbs/ft.
 - b. Over 6 to 13 Feet: 4.000-inch OD pipe weighing at least 10.79 lbs/ft.

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2.3 FITTINGS AND ACCESSORIES

- A. Material: Comply with ASTM F 626. Mill-finished aluminum or Aluminized iron or steel to suit manufacturer's standards.
 - 1. Steel and Iron: Unless specified otherwise, hot-dip Aluminized pressed steel or cast-iron fence fittings and accessories with at least 1.2 oz. zinc per sq. ft. as determined by ASTM A 90.
- B. Post and Line Caps: Supply cone type caps for terminal post, and loop type for line posts.
- C. Post Brace Assembly: Manufacturer's standard adjustable brace. Use material specified below for brace, and truss to line posts with 3/8-inch-diameter rod and adjustable tightener. Provide manufacturer's standard Aluminized-steel cap for each end.
 - 1. Roll-Formed Steel: 1-1/4-by-1-5/8-inch C section weighing a minimum of 1.40 lb per linear ft.
- D. Bottom and Center Rail: Same material as top rail. Provide manufacturer's standard Aluminized-steel, cast-iron or cast-aluminum cap for each end.
- E. Tension Bars: High carbon steel with a minimum length 2 inches less than the full height of fabric, a minimum cross section of 3/16 inch, and a minimum of 1.2 oz. of zinc coating per sq. ft. Provide one bar for each gate and end post, and two for each corner and pull post, except where fabric is integrally woven into the post.
- F. Brace Bands: 12 gauge thickness x 3/4 inch wide, pressed steel.
- G. Page self-lock bands 10 inches on center at post and rail. The Contractor shall not make substitutions.
- H. Swing Gates: Comply with ASTM F 900.
 - 1. Steel: Gates up to 10 feet wide (per panel):
 - a. Up to 6 Feet High: Fabricate perimeter frames of 1.660-inch minimum OD Type I or II steel pipe.
 - b. 6 Feet to 10 Feet High: Fabricate perimeter frames of 1.990 inch OD Type I or II steel pipe.
 - 2. Gate Hardware: Provide Aluminized hardware and accessories for each gate according to the following:
 - a. Hinges: Size and material to suit gate size, non-lift-off type, offset to permit 180-degree gate opening. Provide 1-1/2 pair of hinges for each leaf over 6-foot nominal height.
 - b. Latch: Forked type or plunger-bar type to permit operation from either side of gate, with padlock eye as an integral part of latch.
 - c. Keeper: Provide a keeper for vehicle gates that automatically engages gate leaf and holds it in the open position until manually released.
 - d. Gate Stops: Provide gate stops for double gates consisting of mushroom-type flush plate with anchors, set in concrete, and designed to engage a center drop rod or plunger bar. Include a locking device and padlock eyes as an integral part of the latch, permitting both gate leaves to be locked with a single padlock.

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PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install fence to comply with ASTM F 567. Do not begin installation and erection before final grading is completed, unless otherwise permitted.
 - 1. Apply fabric to outside of framework. Install fencing on boundary lines inside of property line established by survey as required by Division 1.
- B. Excavation: Drill or hand-excavate (using post-hole digger) holes for posts to diameters and spacings indicated, in firm, undisturbed or compacted soil.
 - 1. If not indicated on Drawings, excavate holes for each post to minimum diameter recommended by fence manufacturer, but not less than four times the largest cross section of post.
 - 2. Unless otherwise indicated, excavate hole depths approximately 3 inches lower than post bottom, with bottom of posts set not less than 32 inches below finish grade surface.
- C. Setting Posts: Center and align posts in holes 3 inches above bottom of excavation. Space a maximum of 10 feet o.c., unless otherwise indicated.
 - 1. Protect portion of posts above ground from concrete splatter. Place concrete around posts and vibrate or tamp for consolidation. Check each post for vertical and top alignment, and hold in position during placement and finishing operations.
 - a. Unless otherwise indicated, extend concrete footings 2 inches above grade and trowel to a crown to shed water.
- D. Top Rails: Run rail continuously through line post caps, bending to radius for curved runs and at other posts terminating into rail end attached to posts or post caps fabricated to receive rail. Provide expansion couplings as recommended by fencing manufacturer.
- E. Center Rails: Install center rails in one piece between posts and flush with post on fabric side, using rail ends and special offset fittings where necessary.
- F. Bottom Rails: Install center rails in one piece between posts and flush with post on fabric side, using rail ends and special offset fittings where necessary.
- G. Brace Assemblies: Install braces at end and gate posts and at both sides of corner and pull posts. Locate horizontal braces at midheight of fabric on fences with top rail and at two thirds fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.
- H. Bottom Tension Wire: Install tension wire within 6 inches of bottom of fabric before stretching fabric and tie to each post with not less than same gage and type of wire. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch-diameter (11-gage) hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches o.c.
- I. Top Tension Wire: Install tension wire through post cap loops before stretching fabric. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch-diameter (11-gage) hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches o.c.
- J. Fabric: Leave approximately 2 inches between finish grade and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Install fabric on security side of fence, and anchor to framework so that fabric remains under tension after

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- pulling force is released.
- K. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not over 15 inches o.c.
1. Maximum Spacing: Tie fabric to line posts 12 inches o.c. and to rails and braces 24 inches o.c.
- L. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts for added security.
- 3.2 GATE INSTALLATION
- A. Install gates plumb, level, and secure for full opening without interference. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary. Install gates according to manufacturer's instructions, plumb, level, and secure.
- 3.3 PROJECT CLOSEOUT
- A. All materials used for temporary fencing shall remain the property of the Contractor and shall be removed from the Owner's property.

END OF SECTION

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SECTION 329300 - LANDSCAPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Requirements of the General Provisions apply to all work under this section.
- B. Charles County Government Department of Planning and Growth Management Specifications and details dated July, 1995, revised December 1999 and as amended.

1.2 SUMMARY

- A. This Section includes the following:
 1. Trees
 2. Shrubs
 3. Ground covers
 4. Plants
 5. Lawns
 6. Sod
 7. Topsoil and soil amendments
 8. Softball field infield mix
 9. Fertilizers and mulches
 10. Stakes and guys
 11. Landscape edgings
 12. Transplanting of existing trees and shrubs
- B. Related Sections:
 1. Section 311000: Site Clearing.
 2. Section 312300: Excavating and Filling

1.3 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. LEED Submittals:
 1. Product Data for Credit MR 5: For regional materials, documentation indicating location of manufacture and location of extraction or recovery of primary raw materials. Include statement indicating cost of each product with regional material content.
- C. Product certificates signed by manufacturers certifying that their products comply with specified and Department of Agriculture requirements.
 1. Manufacturer's certified analysis for standard products.
 2. Analysis for other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.
 3. Label data substantiating that plants, trees, shrubs, and planting materials comply with specified requirements.
- D. Certification of grass seed from seed vendor for each grass-seed mixture stating the botanical and common name and percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
 1. Certification of each seed mixture for sod, identifying sod source, including name

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and telephone number of supplier.

- E. Samples of each of the following:
 - 1. 5 lbs. of mineral mulch for each color and texture of stone required for Project, in labeled plastic bags.
 - 2. Edging materials and accessories to verify color selected.
 - 3. Softball Field Infield Mix: Contractor must supply 1 cubic yard of dry weight material of ballfield infield mix, at no cost to the Charles County Public Schools to sample. The samples will be used to determine compliance with the specifications. If sample is in compliance with the specifications, Charles County Public Schools will provide written approval of acceptance of the ballfield infield mix material. The approved sample of the ballfield infield mix material shall be representative of the quality of material to be provided throughout the contract.
- F. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and address of architects and owners, and other information specified.
- G. Material test reports from qualified independent testing agency indicating and interpreting test results relative to compliance of the following materials with requirements indicated.
 - 1. Analysis of existing surface soil.
 - 2. Analysis of imported topsoil.
- H. Planting schedule indicating anticipated dates and locations for each type of planting. Planting schedule shall also include a construction plan and schedule showing locations or locations for storage of trees to be relocated and dates proposed for digging and replanting of trees to be relocated.
- I. Maintenance instructions recommending procedures to be established by Owner for maintenance of landscaping during an entire year. Submit before expiration of required maintenance periods.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced Installer who has completed landscaping work similar in material, design, and extent to that indicated for this Project and with a record of successful landscape establishment.
 - 1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on the Project site during times that landscaping is in progress.
- B. Testing Agency Qualifications: To qualify for acceptance, an independent testing agency must demonstrate to Architect's satisfaction, based on evaluation of agency-submitted criteria conforming to ASTM E 699, that it has the experience and capability to satisfactorily conduct the testing indicated without delaying the Work.
- C. Provide number one quality, size, genus, species, and variety of trees and shrubs indicated, complying with applicable requirements of ANSI Z60.1 "American Standard for Nursery Stock."

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- D. Topsoil Analysis: Furnish a soil analysis made by a qualified independent soil-testing agency stating that topsoil has an organic content by weight, of not less than 4.0 percent, a pH range of 6.0-7.0, and shall not have soluble salts greater than 500 parts per million. Before delivery the topsoil location shall be made known. Each truckload delivered shall be accompanied with an accurate weight verification delivery ticket.
 - 1. Report suitability of topsoil for growth of applicable planting material. State recommended quantities of nitrogen, phosphorus, and potash nutrients and any limestone, aluminum sulfate, or other soil amendments to be added to produce satisfactory topsoil.
- E. Measurements: Measure trees and shrubs according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches above ground for trees up to 4-inch caliper size, and 12 inches above ground for larger sizes. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.
- F. Preinstallation Conference: Conduct conference at Project site to comply with requirements of Division 1 Section "Project Meetings."
- G. Seed Certification: All grass seed shall be certified by the Department of Agriculture and delivered to the site with appropriate tags attached to each seed bag. Tags shall be removed by authorized representative of Charles County Public Schools.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. No trees or shrubs shall be delivered or planted on the site until all construction is completed, unless approved by the Owner.
- B. Packaged Materials: Deliver packaged materials in containers showing weight, analysis, and name of manufacturer. Protect materials from deterioration during delivery and while stored at site.
- C. Seed: Deliver seed in original sealed, labeled, and undamaged containers.
- D. Sod: Time delivery so that sod will be placed within 24 hours after stripping. Protect sod against drying and breaking of rolled strips.
- E. Trees and Shrubs: Deliver freshly dug trees and shrubs. Do not prune before delivery, except as approved by Architect. Protect bark, branches, and root systems from sunscald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy natural shape. Provide protective covering during delivery. Do not drop trees and shrubs during delivery.
- F. Handle balled and burlapped stock by the root ball.
- G. Deliver trees, shrubs, ground covers, and plants after preparations for planting have been completed and install immediately. If planting is delayed more than 6 hours after delivery, set planting materials in shade, protect from weather and mechanical damage, and keep roots moist.
 - 1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
 - 2. Do not remove container-grown stock from containers before time of planting.
 - 3. Water root systems of trees and shrubs stored on site with a fine-mist spray. Water as often as necessary to maintain root systems in a moist condition.

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1.6 PROJECT CONDITIONS

- A. Utilities: Determine location of above grade and underground utilities and perform work in a manner, which will avoid damage. Hand excavate, as required. Maintain grade stakes until removal is mutually agreed upon by parties concerned.
- B. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify Architect before planting.
- C. No frozen sod shall be used, and no sod shall be placed upon frozen soil.

1.7 COORDINATION AND SCHEDULING

- A. Coordinate installation of planting materials during normal planting seasons (see Section 3.2 "Planting Seasons") for each type of plant material required.
- B. Athletic fields shall be constructed during the earliest phases of the construction, after installation of the sediment controls, in order to allow turf grasses to mature.

1.8 WARRANTY

- A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.
- B. Special Warranty: Warrant the following living planting materials for a period of one year after County acceptance of building, against defects including death and unsatisfactory growth. If landscaping is installed after occupancy of building occurs, warranty shall begin after inspection and acceptance of work. Defects resulting from abnormal weather conditions unusual for warranty period, or incidents beyond the contractor's control are not covered by this warranty.
 - 1. Trees
 - 2. Shrubs
 - 3. Ground covers
 - 4. Plants
 - 5. Sod
- C. Replacement shall be during the next planting season. Material and the method of replacement shall be the same as specified for the original planting. All replacements will be inspected for acceptance as per these specifications.
- D. Replace planting materials that are more than 25 percent dead or in an unhealthy condition at end of warranty period. Unacceptable plant and tree material shall be removed from the site and replaced by the Contractor at his own expense.
- E. All replacements shall have a two-year guarantee. The Contractor shall continue to make replacements until a plant or tree shows vigorous and healthy growth for a period of one year from the date of acceptance by the Owner.
- F. Warranty lawns through specified lawn maintenance period.

1.9 TREE, SHRUB AND GROUND COVER MAINTENANCE

- A. Maintain trees and shrubs by pruning, cultivating, watering, weeding, fertilizing, restoring,

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planting saucers, tightening and repairing stakes and guy supports, and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Spray as required to keep trees and shrubs free of insects and disease. Restore or replace damaged tree wrappings. Maintain trees and shrubs until final acceptance and written release.

1.10 LAWN MAINTENANCE

- A. Begin maintenance of lawns immediately after each area is planted and continue until acceptable lawn is established, but for not less than the following periods:
 1. Seeded Lawns: 60 days after date of acceptance of building.
 - a. When full maintenance period has not elapsed before end of planting season, or if lawn is not fully established at that time, continue maintenance during next planting season.
- B. Maintain and establish lawns by watering, fertilizing, weeding, mowing, trimming and other operations. Bare spots which exist after three (3) weeks of favorable growing weather shall be recultivated, reseeded, raked, and rolled as specified in Section 3.5 "Lawn Planting Preparation." Mulching shall be with peat moss. Reseeding of bare spots shall be done as many times as necessary to establish a 95% coverage as determined by the Owner.
- C. Watering: Provide and maintain temporary piping, hoses, and lawn-watering equipment to convey water from sources and to keep lawns uniformly moist to a depth of 4 inches.
 1. Water lawn at the minimum rate of 1 inch per week.
- D. Mow lawns as soon as there is enough top growth to cut with mower set at specified height for principal species planted. Repeat mowing as required to maintain specified height without cutting more than 40 percent of the grass height. Remove no more than 40 percent of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet.
- E. Post-fertilization: Apply fertilizer to lawn after first mowing and when grass is dry.
 1. During the fall apply 10-10-10 fertilizer in three (3) equal applications which will provide a total of 2-22 lbs. of actual nitrogen per 1,000 s.f. Fertilizer shall be granular form and be 50% organic and contain at least 25% of nitrogen in slow release form.
 2. A cosmetic fertilizer application shall be made in mid March of 0.5 lbs. per 1,000 s.f. of slow release nitrogen.
 3. Apply pre-emergent crabgrass control the following spring between April 1st through 15th and follow that with an application of post emergent crabgrass control in early June as needed and apply post emergent broadleaf weed control as needed between May 15th and June 15th.
- F. Final Acceptance of Lawns: Final acceptance of lawns is contingent upon the establishment of a uniform stand of the specified turfgrass at the end of the warranty/maintenance period and shall be in strict compliance with these specifications and without evidence of excessive weed or crabgrass infestation.
 1. The Contractor shall submit a written request to the Owner for final inspection of the established turf.
 2. The request shall be received at least ten (10) calendar days before the anticipated date of inspection and the turfgrass shall be cut immediately prior to the final inspection.
 3. Coverage of the specified turfgrass shall be no less than 95% and weed infestation

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shall not be greater than 5% at the time of final inspection.

- G. Periodical sampling of soil shall be performed in order to monitor and maintain pH. A minimum of two tests are required.

PART 2 - PRODUCTS

2.1 TREE AND SHRUB MATERIAL

- A. General: Furnish no. 1 grade nursery-grown trees and shrubs conforming to ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sunscald, injuries, abrasions, and disfigurement. Provide trees and shrubs harvested within 500 mile radius of Project Site.
- B. Grade: Provide trees and shrubs of sizes and grades conforming to ANSI Z60.1 for type of trees and shrubs required. Trees and shrubs of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.
- C. Where trees and shrubs are not planted in clearly defined groups, label each tree and shrub with securely attached, waterproof tag bearing legible designation of botanical and common name.
- D. Where trees and shrubs are planted in clearly defined groups, label at least 1 tree and 1 shrub, in each group, of each variety and caliper with a securely attached, waterproof tag bearing legible designation of botanical and common name.

2.2 SHADE AND FLOWERING TREES

- A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, conforming to ANSI Z60.1 for type of trees required.
1. Branching Height: 1/3 to 1/2 of tree height.
- B. Small Trees: Small upright or spreading type, branched or pruned naturally according to species and type, and with relationship of caliper, height, and branching recommended by ANSI Z60.1, and stem form as specified.
- C. Provide balled and burlapped trees.

2.3 DECIDUOUS SHRUBS

- A. Form and Size: Deciduous shrubs with not less than the minimum number of canes required by and measured according to ANSI 60.1 for type, shape, and height of shrub.
- B. Provide balled and burlapped deciduous shrubs.
1. Container-grown deciduous shrubs will be acceptable in lieu of balled and burlapped deciduous shrubs subject to meeting ANSI Z60.1 limitations for container stock.

2.4 CONIFEROUS EVERGREENS

- A. Form and Size: Normal-quality, well-balanced, coniferous evergreens, of type, height, spread, and shape required, conforming to ANSI Z60.1.
- B. Provide balled and burlapped coniferous evergreens.

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1. Container-grown coniferous evergreens will be acceptable in lieu of balled and burlapped coniferous evergreens subject to meeting ANSI Z60.1 limitations for container stock.

2.5 BROADLEAF EVERGREENS

- A. Form and Size: Normal-quality, well-balanced, broadleaf evergreens, of type, height, spread, and shape required, conforming to ANSI Z60.1.
- B. Provide balled and burlapped broadleaf evergreens.
 1. Container-grown broadleaf evergreens will be acceptable in lieu of balled and burlapped broadleaf evergreens subject to meeting ANSI Z60.1 limitations for container stock.

2.6 GROUND COVERS AND PLANTS

- A. Provide ground covers and plants established and well rooted in removable containers or integral peat pots and with not less than the minimum number and length of runners required by ANSI Z60.1 for the pot size indicated. Provide ground covers and plants harvested within 500 mile radius of Project Site.

2.7 GRASS MATERIALS

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with the Association of Official Seed Analysts' "Rules for Testing Seeds" for purity and germination tolerances. Provide seeds harvested within 500 mile radius of Project Site.
 1. Seed Mixture: Provide seed of grass species and varieties, proportions by weight, and minimum percentages of purity, germination, and maximum percentage of weed seed as indicated in Seed Mixtures Schedule at the end of this Section.
- B. Seed shall be packed in 50-lbs. net weight in new, clean, poly woven bags, tightly-woven to prevent leaking and contamination. Each container shall have an accurate analysis tag, and a certification tag permanently affixed to it.
- C. All seed shall be delivered within 48 hours after the seed is mixed and tagged, and installed prior to date listed on State Certification.

2.8 SOD

- A. Turf Sod: Provide strongly rooted sod, not less than 2 years old and free of weeds and undesirable native grasses. Provide only sod capable of growth and development when planted (viable, not dormant).
 1. Mixture to conform to seed mix, see paragraph 3.22.
 2. Sod shall be machine cut at a uniform soil thickness of 3/4 inch, plus or minus 1/4 inch, at the time of cutting. Measurement for thickness shall exclude top growth and thatch.
 3. Mowing Height: Height of grass blade not to exceed 3 inches.
 4. Pad Size: Individual pieces of sod shall be cut to the supplier's standard width and length. Maximum allowable deviation from standard widths and lengths shall be 5%. Broken pads and torn or uneven ends will not be acceptable.
 5. Strength of Sod Sections: Standard size sections of sod shall be strong enough to

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- support their own weight and retain their size and shape when suspended vertically from a firm grasp on the upper 10% of the selection.
- 6. Moisture Content: Sod shall not be harvested or transplanted when moisture content (excessively dry or wet) may adversely affect its survival.
 - 7. Time Limitations: Sod shall be harvested, delivered and installed within a period of 24 hours. Sod not transplanted within this period shall be inspected and approved or rejected by the inspection officer or representative prior to its installation.
 - 8. No sod shall be placed between June 1st and August 15th, nor any time when the temperature is below 40° F.

2.9 TOPSOIL

- A. Topsoil: ASTM D 5268, pH range of 6.0 to 7, 4.0 percent organic material minimum, free of stones 3/8 inch or larger in any dimension, roots, plants, sod, clay lumps, and other extraneous materials harmful to plant growth.
 - 1. Topsoil Source: Reuse surface soil stockpiled on the site. Topsoil shall be screened prior to placement so that 100% passes through a #4 sieve. Clean topsoil of roots, plants, sods, stones, clay lumps, and other extraneous materials harmful to plant growth. Verify through testing, the suitability of surface soil to produce topsoil meeting these specified requirements and amend when necessary. If topsoil does not have the properties specified, the Contractor shall add amendments to the topsoil as necessary to bring it to compliance with these specifications. Supplement with imported topsoil when quantities from site are insufficient.
 - a. Imported topsoil: Imported topsoil shall be screened utilizing a #4 sieve size prior to delivery and placement. Topsoil shall be indigenous natural friable loam of uniform composition, obtained from an area, which has never been stripped, possessing characteristics of the best soils of the vicinity, which produce heavy growth of crops, grass and other vegetation. Topsoil shall be of uniform composition with no subsoil, clay lumps stones, roots or similar objects and be free of any parts (seed, rhizomes, roots etc.) of Johnson grass, Canada Thistle, Bermuda grass, Poison Ivy or other noxious weeds and litter or any other material substances which may be harmful to plant growth or a hindrance to planting or maintenance operations, and also contain no rocks over ½", no glass, and/or no metal. Imported topsoil shall contain 20-75% sand, 10-60% silt, 5-30% clay and have 4-10% organic matter as determined by soil composition tests of the Organic Carbon, 6A Chemical Analysis Method described in the Department of Agriculture Soil Survey Investigation Report No.1 dated April 1984. Contractor shall have topsoil tested by a certified testing agency in accordance with USDA Cooperative Extension Service Guidelines. Testing certification shall attest that tested samples meet all specification requirements. The contractor shall pay cost of topsoil testing.
 - 2. Organic matter: Topsoil shall have an organic content, by weight, of not less than 4.0 percent.
 - 3. Soluble salts: Topsoil shall not have soluble salts greater than 500 parts per million.
 - 4. Origin: Before delivery the source of the topsoil shall be made known.
 - 5. Screening: All topsoil, whether from on-site or off-site source shall be screened prior to placement.
 - 6. Depth of topsoil for lawn areas shall be 6" minimum. Random sampling will be taken by Owner's representative after topsoil is distributed and graded to assure minimum 6" depth of topsoil has been achieved after compaction.
 - 7. Depth of topsoil for field areas as shown on landscape plans shall be 6" minimum. The 6" of topsoil on the athletic field areas must meet all requirements listed above.

2.10 SOFTBALL FIELD INFIELD MIX

- A. Ballfield Infield Mix: Dependable Sand Gravel & Stone Company, Inc., P.O. Box 130, Queen Anne, MD 21657, 410-822-6363 or approval equal.

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<u>Sieve Size</u>	<u>% Passing</u>
½	100
#4	95 – 100
#10	85 – 100
#40	65 – 90
#200	20 – 45

- B. Plasticity Index: 3% Max, Plastic Limit 19%, Liquid Limit 22%
- C. Organic Content Percentage: 0.5% Max. (Thomas Rapid Method)
- D. Dry Densities: (ASTM D – 698 – Test Type)
 - Loose 81.9 #/CF
 - Rodded 92.1 #/CF
 - Compacted 113.0 #/CF
- E. Color: Yellow Brown
- F. The contractor cannot proceed with the installation of the ballfield infield mix material until they receive written approval of acceptance from Charles County Public Schools.

2.11 SOIL AMENDMENTS

- A. Lime: ASTM C 602, Class T, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent, with a minimum 99 percent passing a No. 8 sieve and a minimum 75 percent passing a No. 60 sieve.
 - 1. Provide lime in the form of dolomitic limestone.
- B. Aluminum Sulfate: Commercial grade, unadulterated.
- C. Peat Humus: Finely divided or granular texture, with a pH range of 6 to 7.5, composed of partially decomposed moss peat (other than sphagnum), peat humus, or reed-sedge peat.
- D. Peat Humus: For acid-tolerant trees and shrubs, provide moss peat, with a pH range of 3.2 to 4.5, coarse fibrous texture, medium-divided sphagnum moss peat or reed-sedge peat. It shall analyze to at least 90% organic matter and contain not more than 60% moisture. Spaghnum type of peat moss is not acceptable.
- E. Water: Potable.

2.12 FERTILIZER

- A. Bonemeal: Commercial, raw, finely ground; minimum of 4 percent nitrogen and 20 percent phosphoric acid.
- B. Superphosphate: Commercial, phosphate mixture, soluble; minimum of 20 percent available phosphoric acid.
- C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of ureaform, phosphorous, and potassium in the following composition:

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1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

2.13 MULCHES

- A. Organic Mulch: Organic mulch, free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of shredded hardwood.

2.14 WEED-CONTROL BARRIERS

- A. Nonwoven Fabric: Polypropylene or polyester fabric, 3 oz. per sq. yd. minimum.
- B. Composite Fabric: Woven, needle-punched Polypropylene substrate bonded to a nonwoven Polypropylene fabric, 4.8 oz per sq. yd.

2.15 EROSION-CONTROL MATERIALS

- A. Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.
- B. Fiber Mesh: Biodegradable twisted jute or spun-coir mesh, 0.92 lb. per sq. yd. minimum, with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches long.

2.16 STAKES AND GUYS

- A. Guy Stakes shall be oak, locust, white cedar, or approved equal. Sound hardwood of uniform size, decay free, straight, and 1-1/2" square by 2 feet long.
- B. Upright stakes shall be oak, locust, white cedar, or approved equal. Sound hardwood of uniform size, decay free, straight and not less than 1-1/2" or more than 2-1/4" in width. Length as required for proper tree staking per details.
- C. Staking Wire shall be No. 12 gauge galvanized annealed wire.
- D. Guying Hose shall be 1/2" ID fabric bearing garden hose or an approved equal guying material. Guying hose shall be uniform in color.
- E. Deadman shall be redwood, cedar, or approved equal sound hardwood of uniform size, decay free, in good condition and 6" by 6" by 3 feet long.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive landscaping for compliance with requirements and for conditions affecting performance of work of this Section. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 PLANTINGS SEASONS

- A. All planting shall be performed during the regular planting season for various types of plant material as follows:

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1. Deciduous trees and shrubs are to be planted during late fall (October 1 through November 15) and early spring (March through mid-May).
2. Evergreen trees and shrubs are to be planted during fall (August through September) and early spring (March through mid-May).

3.3 PREPARATION

- A. The location of all planting beds shall be staked out by the Contractor prior to planting and such location stakes shall be approved by the Charles County Public Schools before planting operations will be permitted to proceed.

3.4 PLANTING SOIL PREPARATION

- A. Before mixing, clean topsoil of roots, plants, sods, stones, clay lumps, and other extraneous materials harmful to plant growth.
- B. Mix soil amendments and fertilizers with topsoil at rates indicated. Delay mixing fertilizer if planting does not follow placing of planting soil within a few days.
- C. For tree pit or trench backfill, mix planting soil before backfilling and stockpile at site.
- D. For planting beds and lawns, mix planting soil either prior to planting or apply on surface of topsoil and mix thoroughly before planting.
 1. Mix lime with dry soil prior to mixing fertilizer. Prevent lime from contacting roots of acid-tolerant plants.
 2. Apply phosphoric acid fertilizer, other than that constituting a portion of complete fertilizers, directly to subgrade before applying planting soil and tilling.

3.5 LAWN PLANTING PREPARATION

- A. Limit subgrade preparation to areas that will be planted in the immediate future.
- B. Loosen subgrade to a minimum depth of 4 inches. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous materials.
- C. Spread planting soil mixture to depth required to meet thickness, grades, and elevations shown, after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen.
 1. Place approximately 1/2 the thickness of planting soil mixture required. Work into top of loosened subgrade to create a transition layer and then place remainder of planting soil mixture.
- D. Grade lawn and grass areas to a smooth, even surface with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit fine grading to areas that can be planted in the immediate future. Remove trash, debris, stones larger than 1/2 inch in any dimension, and other objects that may interfere with planting or maintenance operations.
- E. Moisten prepared lawn areas before planting when soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- F. Restore prepared areas if eroded or otherwise disturbed after fine grading and before planting.

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3.6 GROUND COVER AND PLANT BED PREPARATION

- A. Remove soil to a minimum depth of 18 inches below finished grade and 24 inches beyond perimeter of the proposed planting bed and dispose offsite. Replace with prepared planting soil mixture.
- B. Final grades for landscaping beds shall be 6" above existing ground level.

3.7 EXCAVATION FOR TREES AND SHRUBS

- A. Pits and Trenches: Excavate with vertical sides and with bottom of excavation slightly raised at center to assist drainage. Loosen hard subsoil in bottom of excavation.
 1. Balled and Burlapped Trees and Shrubs: Excavate approximately 2 times as wide as ball diameter and equal to ball depth, plus the following setting layer depth:
 - a. Setting Layer: Allow 6-8 inches of planting soil.
 2. Where drain tile is shown or required under planted areas, excavate to top of porous backfill over tile.
- B. Preparation of Shrub Beds: All landscape beds shall have existing soil removed to a depth of 18" below grade and two feet beyond its perimeter.
- C. Subsoil excavated from the plant pits shall be removed from the site unless otherwise notified, in writing by the Owner. Do not mix with planting soil or use as backfill.
- D. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
 1. Hardpan Layer: Drill 6-inch diameter holes into free-draining strata or to a depth of 10 feet, whichever is less, and backfill with free-draining material.
- E. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub pits.
- F. Fill excavations with water and allow to percolate out, before placing setting layer and positioning trees and shrubs.

3.8 PLANTING TREES AND SHRUBS

- A. Set balled and burlapped stock plumb and in center of pit or trench with top ball raised above adjacent finish grades as indicated.
 1. Place stock on setting layer of compacted planting soil.
 2. Remove burlap and wire baskets from tops of balls and partially from sides, but do not remove from under balls. Remove pallets, if any, before setting. Do not use planting stock if ball is cracked or broken before or during planting operation. All burlap, ropes, staples, and other items used in balling and burlapping shall be removed from the site by the Contractor.
 3. Place backfill around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately ½ backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing and tamping final layer of backfill. No air pockets shall be left about the roots.
- B. Set container-grown stock plumb and in center of pit or trench with top of ball raised above

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adjacent finish grades as indicated.

1. Carefully remove containers so as not to damage root balls.
 2. Score roots of container plants with a sharp knife, 4 to 5 times, 1" deep around the perimeter of the plant.
 3. Place stock on setting layer of compacted planting soil.
 4. Place backfill around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately $\frac{1}{2}$ backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing and tamping final layer of backfill. No air pockets shall be left about the roots.
- C. Dish and tamp top of backfill to form a 3-inch high mound around the rim of the pit. Do not cover top of root ball with backfill.

3.9 TREE AND SHRUB PRUNING

- A. Prune, thin, and shape trees and shrubs according to standard horticultural practice. Prune trees to retain required height and spread. Unless otherwise directed by Architect, do not cut tree leaders; remove only injured or dead branches from flowering trees. Prune shrubs to retain natural character. Shrub sizes indicated are size after pruning. Pruning shall be done with clean sharp instruments. All injured tree and shrub roots shall be pruned to make clean ends before planting.

3.10 TREE AND SHRUB GUYING AND STAKING

- A. All trees shall be supported immediately after planting. Wires shall be encased in fabric bearing hose as necessary to prevent contact with the bark of the tree and shall be placed around the trunk in a single loop. Rubber hose and wire shall not be placed in such as manner as to pull apart at a crotch of the tree. Wire shall be tightened and kept taut by using turnbuckles.
- B. Staking trees of less than 3" caliper: All trees shall be staked as follows: Trees shall be supported in an upright position by two stakes as shown on the plans. The stakes shall be spaced approximately 12" from the trunk and in the case of balled and burlapped trees outside the perimeter of the ball. Stakes shall be driven vertically into the ground to a depth of at least 2 to 3 feet and shall not be twisted or pulled in such a manner as to cause injury to the ball or roots. The tree shall be wired to each stake, near the top, with two strands of wire.
- C. Guying trees more than 3" caliper shall be guyed as follows: Trees shall be supported in an upright position by three guys equally spaced around the tree. Each guy shall consist of two strands of wire and be attached to the tree trunk at an angle of 60° at $\frac{2}{5}$ of the height of the tree. The guys shall be anchored at the ground in one of the following methods:
 1. Stakes which have been driven into the ground at an angle away from the tree so that the tops of the anchor stakes are below finished grade.
 2. Deadman placed at least three feet below finished grade.

3.11 PLANTING GROUND COVER AND PLANTS

- A. Space ground cover and plants as indicated.
- B. Space ground cover and plants not more than 24 inches apart.
- C. Dig holes large enough to allow spreading of roots, and backfill with planting soil. Work soil

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around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water. Water thoroughly after planting, take care not to cover plant crowns with wet soil.

3.12 MULCHING

- A. Mulch backfilled surfaces of pits, trenches, planted areas, and other areas indicated.
- B. Organic Mulch: Apply the following average thickness of organic mulch and finish level with adjacent finish grades. Do not place mulch against trunks or stems.
 1. Thickness: 3 inches.
- C. Mulch shall be applied within two days after planting of plant or landscape bed.
- D. A sample of the mulch shall be approved by the Charles County Public Schools before installation.
- E. After raking the surface smooth and even, the mulch shall be thoroughly soaked for its full depth.

3.13 SEEDING NEW LAWNS

- A. Sow seed with a spreader or a seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in 2 directions at right angles to each other.
 1. Do not use wet seed or seed that is moldy or otherwise damaged in transit or storage.
- B. Sow seed at the following rates:
 1. Seeding Rate: 8 to 9 lbs per 1000 sq. ft.
- C. Rake seed lightly into top 1/8 inch of topsoil, roll lightly, and water with fine spray.
- D. Protect seeded slopes exceeding 1:4 against erosion with erosion-control blankets installed and stapled according to manufacturer's recommendations.
- E. Protect seeded slopes exceeding 1:6 against erosion with jute or coir-fiber erosion-control mesh installed and stapled according to manufacturer's recommendations.
- F. Protect seeded areas with slopes less than 1:6 against erosion by spreading straw mulch after completion of seeding operations. Spread uniformly at a minimum rate of 2 tons per acre to form a continuous blanket 12 inches loose depth over seeded areas. Spread by hand, blower, or other suitable equipment.
 1. Anchor straw mulch by crimping into topsoil by suitable mechanical equipment.
 2. Anchor straw mulch by spraying with nitro-cellulose tackifier at the rate of 10 to 13 gal. per 1000 sq. ft. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.
- G. Protect seeded areas against hot, dry weather or drying winds by applying peat mulch

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within 24 hours after completion of seeding operations. Soak and scatter uniformly to a depth of 3/16 inch thick and roll to a smooth surface.

3.14 HYDROSEEDING NEW LAWNS

- A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogenous slurry suitable for hydraulic application.
 1. Mix slurry with nonasphaltic tackifier.
 2. Apply slurry uniformly to all areas to be seeded in a 1-step process. Apply mulch at the minimum rate of 1500 lb per acre dry weight but not less than the rate required to obtain specified seed-sowing rate.

3.15 RECONDITIONING LAWNS

- A. Recondition existing lawn areas damaged by Contractor's operations, including storage of materials or equipment and movement of vehicles. Also recondition lawn areas where settlement or washouts occur or where minor grading is required.
- B. Remove sod and vegetation from diseased or unsatisfactory lawn areas; do not bury into soil. Remove topsoil containing foreign materials resulting from Contractor's operations, including oil drippings, fuel spills, stone, gravel, and other construction materials, and replace with new topsoil.
- C. Where substantial lawn remains, mow, dethatch, core aerate, and rake. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergent herbicides.
- D. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of it off the Owner's property.
- E. Till stripped, bare, and compacted areas thoroughly to a depth of 6 inches.
- F. Apply required soil amendments and initial fertilizers and mix thoroughly into top 4 inches of soil. Provide new planting soil as required to fill low spots and meet new finish grades.
- G. Apply seed and protect with straw mulch as required for new lawns.
- H. Water newly planted areas and keep moist until new grass is established.

3.16 SODDING

- A. Installation Procedures for Sod:
 1. Moistening the Soil: During periods of high temperature, after all unevenness in the soil surface has been corrected, the soil shall be lightly irrigated immediately prior to laying the sod.
 2. Starter Strip: The first row of sod shall be laid in a straight line with subsequent rows placed parallel to and tightly against each other. Lateral joints shall be staggered to promote more uniform growth and strength. Care shall be exercised to insure that the sod is not stretched or overlapped and that all joints are butted tightly in order to prevent voids which would cause air drying of the roots.
 3. Sloping Surfaces: On sloping areas 3:1 or steeper, or where erosion may be a problem, sod shall be laid parallel to the contours of the slope (perpendicular to the

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flow of water), with staggered joints, and secured by at least two (2) non treated pine or coniferous wood stakes spaced not more than two (2) feet apart. Stakes shall be driven flush with top of the sod. No metal staples or pegs may be used. When placing sod in drainage ditches, the length of the strip shall be laid parallel to the direction of the flow of the water.

4. Watering and Rolling: The landscape contractor shall lightly water sod during installation to prevent excessive drying. As sodding is completed in any one section, the entire area shall be rolled with a 1/2 ton roller properly leveled. It shall then be thoroughly irrigated so that the underside of the new sod pad and soil immediately below the sod are thoroughly wet (to a depth of 2-4"). Watering shall be accomplished as necessary until the sod is established or until acceptance of the work.

3.17 INSTALLATION OF EDGINGS

- A. Steel Edging: Install steel edging where indicated according to manufacturer's recommendations. Anchor with steel stakes spaced approximately 30 inches apart, driven below top elevation of edging.

3.18 INSTALLATION OF MISCELLANEOUS MATERIALS

- A. Apply antidesiccant using power spray to provide an adequate film over trunks, branches, stems, twigs, and foliage.
 1. When deciduous trees or shrubs are moved in full-leaf, spray with antidesiccant at nursery before moving and again 2 weeks after planting.

3.19 CLEANUP AND PROTECTION

- A. During the course of planting, excess waste material shall be continuously and promptly removed, lawn areas kept clean, and all reasonable precautions shall be taken to avoid damage to existing structures, plants, and grass areas.
- B. Existing grass areas, which have been injured by this work, shall be regraded to the original grade. When completed the entire area shall be neat and clean to the satisfaction of Charles County Public Schools.
- C. Immediately after all pruning, staking, and mulching have been completed; the Contractor shall remove all branches, excavated soil, and construction debris.

3.20 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Promptly remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of it off the Owner's property.

3.21 PLANTING SOIL AMENDMENTS SCHEDULE

- A. Tree Pits or Trenches: Provide soil amendments in not less than the following quantities:
 1. Ratio of loose peat humus to topsoil by volume: 1:4.
 2. Commercial fertilizer in amounts recommended in soils report from a qualified soil-testing agency. Fertilizer shall be mixed evenly into the backfill mix.
- B. Ground Cover and Planting Beds: Provide soil amendments in not less than the following quantities:

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1. Ratio of loose peat humus to topsoil by volume: 1:4.
 2. Commercial fertilizer in amounts recommended in soils report from a qualified soil-testing agency. Fertilizer shall be spread evenly over the area to be planted and cultivated into the soil mix to a depth of six (6) inches minimum.
- C. Lawns:
1. Spread four (4) inches of topsoil over finished subgrade unless otherwise indicated.
 2. Apply lime, fertilizer, and other soil amendments in amounts recommended in soils report from a qualified soil-testing agency.
 3. Apply 10-22-22 analysis granular fertilizer (50% UFN₂) at a rate of twenty three (23) pounds per 1000 square feet.
 4. Apply granular limestone at a rate of one hundred thirty (130) pounds per 1000 square feet.

3.2 SEED MIXTURES SCHEDULE

- A. Seed mixes shall be composed of the following varieties according to use and tested to the following minimum percentages of purity and germination.

GRASS SEED MIXTURES			
Use	Irrigated play fields and general areas	Non-irrigated playing fields	Maintenance seeding
Product	LESCO Premium Athletic Mix	LESCO Team Mates Plus mix	LESCO Eagle Blend plus Blue
LESCO #	001365	019586	011942
Mixture	70% premium Kentucky Bluegrass 30% premium turf-type perennial ryegrass	70% premium turf-type tall fescues 20% premium turf-type perennial ryegrass 10% premium Kentucky Bluegrass	75% premium turf-type perennial ryegrass 25% premium Kentucky Bluegrass
Rate/ 1000 s.f.	4 lbs.	8 lbs.	6 lbs.

B. NOTES:

1. Improved varieties of each species are required.
2. Tall fescue mix is to contain any two (2) certified varieties from the latest issue of the University of Maryland Memorandum No. 77, dated April 1992. (K-31 is not acceptable)
3. Kentucky Bluegrass shall contain 3 certified varieties selected from the following list: Baron, Cheri, Columbia, Monopoly, Ram 1 and Victa.
4. All seed must be free of all prohibited and restricted noxious weeds in accordance with Maryland law.
5. Seed lots must be blended and certified as per the general certification specifications

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- of the Maryland Department of Agriculture.
- 6. Seed filing must comply with the Maryland Seed and Regulations law.
 - 7. All seed must be certified with complete and accurate analysis tags attached to each container.
 - 8. Seed mixes for SWM planting areas are to comply with approved SWM drawings.
 - 9. Tags shall be removed by an authorized representative of Charles County Public Schools.

END OF SECTION

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SECTION 333000 - SANITARY SEWERAGE UTILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Charles County Government Department of Planning and Growth Management Specifications and details dated July, 1995, revised December 1999 and as amended.
- C. Maryland Department of Transportation State Highway Administration Standard Specifications for Construction and Materials, dated January, 2008 and as amended.

1.2 SUMMARY

- A. This Section includes sewage disposal systems.
- B. Related Sections:
 - 1. Section 017700: Closeout Procedures
 - 2. Section 033000: Cast-In-Place Concrete
 - 3. Section 221300: Facility Sanitary Sewerage

1.3 DEFINITIONS

- A. Wastewater: Sewage, water or other liquid requiring disposal.

1.4 PERFORMANCE REQUIREMENTS

- A. The Contractor will be responsible for securing all appropriate utility permits, including but not limited to an on-site sewer permit.
- B. Solid Piping Rating: At least equal to system operating pressure.

1.5 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Shop drawings for the following precast, reinforced-concrete structures, including manhole openings, covers, pipe connections, and accessories.
- C. Coordination drawings showing piping, underground structures, and other utilities. Indicate size and invert elevations of piping and structures.
- D. Record drawings at project closeout of installed sanitary sewer system piping and products according to Division 1 Section "Closeout Procedures", and "Project Record Documents".

1.6 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with provisions of the local health department and authorities having jurisdiction.

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- B. In the event of a discrepancy between the Project Specifications, Construction Documents, Charles County Standard Specifications and Details, or other guidelines set forth by the authorities having jurisdiction, the more stringent will apply.
- C. Cast iron fittings and ductile iron pipe (DIP) and fittings shall be sound and without defects that might impair its service. Defective areas shall not exceed the maximum allowable minus wall thickness tolerance specified in AWWA C110 or C151. Repair of defects by welding or other methods will not be allowed. Defective or damaged lining areas may be repaired by cutting out the defective or damaged lining to the metal so that the edges of the lining not removed are perpendicular or slightly undercut. The cutout area and the adjoining lining shall be thoroughly wetted, and a stiff mortar applied and troweled smooth with the adjoining lining. After any surface water has evaporated, but while the patch is still moist, it shall be cured by the application of a seal coat.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic pipe or fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.
- C. Handle pre-cast concrete structures according to manufacturers rigging instructions.

1.8 PROJECT CONDITIONS

- A. Site Information Data in subsurface investigation reports was used for the basis of the design. The data in the subsurface investigation report is not a part of the Contract. Conditions are not intended as representations or warranties of accuracy or continuity between soil borings. The Owner, Architect or Engineers will not be responsible for interpretations or conclusions drawn from this data by the Contractor.
 - 1. Additional test borings and other exploratory operations may be performed by the Contractor, at the Contractor's option; however, no change in the Contract Sum will be authorized for such additional exploration.
- B. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted in writing by the Architect and then only after acceptable temporary utility services have been provided. If existing utilities are indicated to be abandoned, the Contractor shall remove such utility, if necessary, at no additional cost to the Owner.
 - 1. Provide a minimum 48-hours' notice to the Architect and receive written notice to proceed before interrupting any utility.

PART 2 - PRODUCTS

2.1 PIPES AND FITTINGS

- A. Refer to Part 3 "Piping Applications" Article for identification of systems where piping materials specified below are used.
- B. Polyvinyl Chloride (PVC) Sewer Pipe and Fittings: ASTM D 1785, SCH 40, nonperforated, for solvent-cement or elastomeric gasket joints.
 - 1. Solvent Cement: ASTM D 2564.
 - 2. Gaskets: ASTM F 477, elastomeric seal.
- C. Polyvinyl Chloride (PVC) Sewer Pipe and Fittings: ASTM D 3034, SDR 26, nonperforated, for

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solvent-cement or elastomeric gasket joints.

1. Solvent Cement: ASTM D 2564.
2. Gaskets: ASTM F 477, elastomeric seal.

D. Ductile Iron Pipe and fittings

1. Pipe
 - a) Pipe shall be manufactured in accordance with the requirements of AWWA C151 except that the metal thickness shall be as described herein. Pipe nominal lengths may be 16 through 20 feet.
 - b) All pipe and fittings shall be designed and constructed to withstand all external pressure caused by overburden as indicated on the profile and traffic loads to which the pipe may be subjected.
 - c) Ductile iron pipe and ductile iron and cast iron fittings shall be cement-lined in accordance with AWWA C 104, double thickness. This lining shall be sealed with a bituminous seal coat. The outside surfaces shall be bituminous coated.
2. Joints
 - a) Joints may be mechanical or rubber gasketed push-on type. Unless otherwise noted, all joints shall be in accordance with AWWA C111.
3. Fittings
 - a) All fittings shall be manufactured in accordance with AWWA C110 or AWWA C 153 for compact fittings sizes 3 inch through 16 inch. Fittings shall be designed and constructed to withstand a pressure not less than that for the adjacent pipe.
4. Lining and Coating
 - a) All pipe and fittings shall be cement-lined in accordance with AWWA C104, double thickness. This lining shall be sealed with a bituminous seal coat. The outside surface shall be bituminous coated.

E. Sleeve-Type Couplings: Rubber or elastomeric sleeve and band assembly fabricated to match outside diameters of pipes to be joined.

1. Sleeves for Plastic Pipe: ASTM F 477, elastomeric seal.
2. Bands: Stainless steel, at least one at each pipe insert.

F. Gasket-Type Couplings: Rubber or elastomeric compression gasket, made to match outside diameter of smaller pipe and inside diameter or hub or adjoining larger pipe.

1. Gaskets for Plastic Pipe: ASTM F 477, elastomeric seal.
2. Gaskets for Dissimilar Pipes: Compatible with pipe materials being joined.

2.2 CLEANOUTS

- A. Description: ASME A112.36.2M, with round, flanged, cast-iron housing, and secured scoriated, medium-dry loading class, cast-iron cover. Include cast-iron ferrule and countersunk brass

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cleanout plug.

2.3 MANHOLES

- A. Precast Concrete Manholes: ASTM C 478, precast reinforce concrete, of depth indicated, with provision for rubber gasket joints, and frame and cover; all in accordance with Charles County Standard Details. Include indented top design with lettering, equivalent to the following cast into cover:

1. Sanitary Sewer Piping Systems: Sanitary Sewer

2.4 PROTECTIVE COATINGS

- A. General: Include factory - or field-applied protective coatings to structures and appurtenances according to the following:

1. In accordance with the Charles County Department of Public Works Specifications for Sanitary Sewer Manholes.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 31 Section 312300.

3.2 IDENTIFICATION

- A. Identification materials and their installation are specified in Division 2 Section "Excavating and Filling". Arrange for installation of green warning tapes directly over piping (including absorption field piping), at outside edges of underground structures, and at outside edges of seepage pits.

1. Use detectable warning tape over edges of underground structures, edges of seepage pits, and over nonferrous piping.

3.3 GENERAL INSTALLATION

- A. Installation: Installation shall be in accordance with the requirements of the Charles County Specifications, and in accordance with the Drawings.

- B. Where installation details are not shown on the Drawings, installation shall be in accordance with the Charles County Standard Details.

- C. Termination: Terminate piping 5' from building foundation in location as indicated. Provide temporary pipe plug for piping extension into building by work of Division 22.

3.4 PIPING APPLICATIONS

- A. Use pipes, fittings, and joining methods, for all piping sizes, according to the following applications.

3.5 PIPE JOINT CONSTRUCTION AND INSTALLATION

- A. Join and install polyvinyl chloride (PVC) pipe as follows:

1. Join solvent-cement type pipe and fitting with solvent cement according to ASTM D 2855 and ASTM F402.

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2. Join gasketed pipe and fittings with elastomeric seals according to ASTM D 3212.
3. Install solid piping according to ASTM D 2321.

3.6 CLEANOUT INSTALLATION

- A. Install cleanouts and extension for mapping to cleanout at grade as indicated. Set cleanout housing and cover in concrete block 18 by 18 by 12 inches deep, except where location is in concrete paving. Set top of cleanout 1 inch above surrounding earth grade, or flush with grade when installed in paving.
- B. Cleanout installed in paving shall have countersunk lid.
- C. Refer to Division 3 Section "Cast-in-Place Concrete" for formwork, reinforcing and concrete.

3.7 CONNECTIONS

- A. Install standard manhole over existing sanitary sewer and connect proposed sanitary.

3.8 FIELD QUALITY CONTROL

- A. System Tests: After installation, pipe shall be inspected visually for deflections and misaligned pipe sections.
 1. PVC sewer pipe shall be tested for deflection in accordance with Charles County requirements.
 2. All sewers shall be air tested in accordance with Charles County requirements, except that Contractor shall supply all materials needed for testing.
 3. Additional Tests: Fill underground structures with water and let stand overnight. If water level recedes, locate and repair leaks and retest. Repeat tests and repair until there is no leakage.
 4. Cleaning: Clear interior of piping and structures of dirt and other superfluous materials as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of day or whenever work stops.

END OF SECTION 33 30 00

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SECTION 334000 - STORM DRAINAGE UTILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Charles County Government Department of Planning and Growth Management Specifications and details dated July, 1995, revised December 1999 and as amended.
- C. Maryland Department of Transportation State Highway Administration Standard Specifications for Construction and Materials, dated January, 2008 and as amended.

1.2 SUMMARY

- A. This Section includes drainage systems outside the building. Systems include the following:
 - 1. Storm drainage
- B. Related Sections:
 - 1. Section 017700: Closeout Procedures

1.3 DEFINITIONS

- A. Drainage Piping: System of sewer pipe, fittings, and appurtenances for gravity flow of storm drainage.

1.4 PERFORMANCE REQUIREMENTS:

- A. Gravity-Flow, Nonpressure-Piping Pressure Ratings: At least equal to system test pressure.
- B. Stormwater Management Permit: Stormwater management facilities shall be constructed in accordance with the approved drawings and the provisions of the Stormwater Management Permit.
- C. Certification of Completed Facilities: As-Built and Certifications are required for this stormwater management facility. In order to properly prepare these documents, this stormwater management facility must be inspected by a Registered Professional Engineer at specific stages of the construction. The Contractor shall notify the Certifying Engineer and Owner at least five (5) working days prior to starting work on this stormwater management facility. The Contractor shall also contact the Certifying engineer at least two (2) working days prior for each required inspection item shown on the contract documents. Preparation and processing of the As-Built Plans and Certification will be the responsibility of the Owner.

1.5 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for the following:
 - 1. Cleanouts.
 - 2. Piping.
 - 3. Fittings.

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- C. Shop drawings for precast concrete manholes and other structures. Include frames, covers and grates.
- D. Shop drawings for cast-in-place concrete or field-erected masonry manholes and other structures. Include frames, covers and grates.
- E. Reports and calculations for design mixes for each class of cast-in-place concrete.
- F. Inspection and test reports specified in the "Field Quality Control" Article.
- G. Record drawings at Project closeout of installed water system piping and products according to Division 1 Section "Closeout Procedures", and "Project Record Documents".

1.6 QUALITY ASSURANCE

- A. Environmental Agency Compliance: Comply with regulations pertaining to sanitary sewerage and storm drainage systems.
- B. Utility Compliance: Comply with regulations pertaining to sanitary sewerage and storm drainage systems. Include standards of water and other utilities where appropriate.
- C. Product Options: Drawings indicate sizes, profiles, connections, and dimensional requirements of system components and are based on specific manufacturer types indicated. Other manufacturer's products with equal performance characteristics may be considered.
- D. In the event of a discrepancy between the Project Specifications, Construction Documents, Charles County requirements, or other guidelines set forth by the authorities having jurisdiction the more stringent will apply.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic structures in direct sunlight.
- B. Do not store plastic pipe or fittings in direct sunlight.
- C. Protect pipe, pipe fittings, and seals from dirt and damage.
- D. Handle precast concrete manholes and other structures according to manufacturer's rigging instructions.

1.8 PROJECT CONDITIONS

- A. Site Information: Data in subsurface investigation reports was used for the basis of the design. The data in the subsurface investigation report is not a part of the Contract. Conditions are not intended as presentations or warranties of accuracy or continuity between soil borings. The Owner, Architect or Engineers will not be responsible for interpretations or conclusions drawn from this data by the Contractor.
 - 1. Additional test borings and other exploratory operations may be performed by the Contractor, at the Contractor's option; however, no change in the Contract Sum will be authorized for such additional exploration.
- B. Locate existing structures and piping to be closed and abandoned.
- C. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted under the following conditions and then only after arranging to provide acceptable temporary utility services.

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1. Notify Architect not less than 48 hours in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without receiving Architect's written permission.
- D. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.

1.9 SEQUENCING AND SCHEDULING

- A. Coordinate with interior building drainage systems.
- B. Coordinate with other utility work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Cleanouts
 - a. Ancon, Inc.
 - b. Jones Manufacturing Co., Inc.
 - c. Josam Co.
 - d. Rockford Sanitary Systems, Inc.
 - e. Jay R. Smith Mfg. Co. Div., Smith Industries, Inc.
 - f. Wade Div., Tyler Corp.
 - g. Zurn Industries, Inc., Hydromechanics Div.
 2. High Density Polyethylene (HDPE) pipe and fittings
 - a. Hancor
 - b. Advance Drainage Systems (ADS)
 - c. Lane Enterprises

2.2 PIPES AND FITTINGS

- A. Polyvinyl Chloride Schedule 40 (P.V.C. SCH40)(watertight).
- B. Polyvinyl Chloride SDR 26 (P.V.C. SDR26)(watertight)
- C. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76, Class IV, Wall B, for gasketed joints.
 1. Gaskets: ASTM C 443, rubber.
- D. High Density Polyethylene (HDPE) pipe and fittings. Watertight Joint

2.3 SPECIAL PIPE COUPLINGS AND FITTINGS

- A. Sleeve-Type Pipe Couplings: Rubber or elastomeric sleeve and band assembly fabricated to match outside diameters of pipes to be joined, for nonpressure joints.
 1. Sleeves for Concrete Pipe: ASTM C 443 (ASTM C 443M), rubber.

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2. Sleeves for Plastic Pipe: ASTM F 477, elastomeric seal.
3. Sleeves for Dissimilar Pipes: Compatible with pipe materials being joined.
4. Bands: Stainless steel, at least one at each pipe insert.

2.4 MANHOLES

- A. Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for rubber gasket joints, and frame and cover, all in accordance with Charles County Standard Details. Include indented top design with lettering, equivalent to the following, cast into cover:

1. Storm Drainage Piping Systems: STORM SEWER.

2.5 STORM DRAIN INLETS

- A. General: Pre-cast reinforced concrete, or cast-in-place concrete complete with frames and grates, all in accordance with Charles County Standard Details or as otherwise noted on the plans.

2.6 CONCRETE

- A. General: Cast-in-place concrete according to ACI 318, ACI 350R, and the following:

1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

- B. Structures: Portland-cement design mix, 4000 psi minimum, with 0.45 maximum water-cement ratio.

1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
2. Reinforcement Bars: ASTM A 615, Grade 60, deformed steel.

- C. Structure Channels and Benches: Factory or held formed from concrete. Portland-cement design mix, 4000 psi minimum, with 0.45 maximum water-cement ratio.

1. Include channels and benches in manholes.

- a. Manholes Channels: Concrete invert, formed to same width as connected piping, with height of the vertical sides to 3/4 of the pipe diameter. Form curved channels with smooth, uniform radius and slope.
 - (1) Invert Slope: 2.5 percent (1:40) through manhole.
 - (2) Manhole Benches: Concrete, sloped to drain into channel.
 - (a) Slope: 1 inch per foot (1:12).

- b. Include channels and benches in storm drain inlets.

- (1) Storm Drain Inlet Channels: Concrete invert, formed to same width as connected piping, with height of the vertical sides to 3/4 of the pipe

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diameter. Form curved channels with smooth, uniform radius and slope.

(a) Invert Slope: 2.5 percent (1:40) through inlet.

(2) Storm Drain Inlet Benches: Concrete, sloped to drain into channel.

(b) Slope: 1 inch per foot (1:12).

2. Ballast and Pipe Supports: Portland-cement design mix, 3000 psi minimum, with 0.58 maximum water-cement ratio.

a. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.

b. Reinforcement Bars: ASTM A 615, Grade 60, deformed steel.

2.7 PROTECTIVE COATINGS

A. General: Include factory - or field-applied protective coatings to structures and appurtenances according to the following:

1. In accordance with the Charles County Department of Public Works Specifications for Storm Drain Manholes.

2.8 CLEANOUTS

A. Description: ASME A112.36.2M, round, cast-iron housing with clamping device and found, secured, scoriated, cast-iron cover. Include cast-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug. Use units with top-loading classifications according to the following applications:

1. Light Duty: In earth or grass, foot-traffic areas.

2. Medium Duty: In paved, foot-traffic areas.

3. Heavy Duty: In vehicle-traffic service areas.

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2.9 RIPRAP

- A. Stone for riprap shall be uniformly graded from the smallest to the largest pieces as specified in the Contract Documents. The stone will be accepted upon visual inspection at the point of usage, and shall conform to the following:

CLASS OF RIPRAP	WEIGHT RANGES lb (kg)	APPROX. SIZE in. (mm)
0	1-33 (0.5 – 15)	2-7 (50-175)
I	2-150 (1-70)	3-12 (75-300)
II	20-700 (10-320)	6-20 (150-500)
III	40-2000 (20-910)	8-28 (200-700)

2.10 GEOTEXTILES

- A. Geotextiles shall conform to the class specified in the Contract Documents. The geotextile shall be manufactured from fibers consisting of long chain synthetic polymers, composed of a minimum 85 percent by weight of polyolephins, polyesters or polyamides. The geotextile shall resist deterioration from ultraviolet exposure. Geotextiles used in the construction of silt fence shall contain sufficient amounts of ultraviolet ray inhibitors and stabilizers to provide a minimum of 12 months of expected usable construction life at a temperature range of 0 to 120F (-18 to 49 C).
- B. All values specified are minimum or maximum roll values.
- C. Classes A through E Geotextiles shall have a 0.010 cm/sec minimum permeability when tested in conformance with D4491, and an apparent minimum elongation of 20 percent when tested for conformance with the grab tensile strength requirements specified below. Classes A through E Geotextiles shall also conform to the following additional requirements:

GEOTEXTILE CLASS	MAXIMUM APPARENT OPENING SIZE mm	GRAB TENSILE STRENGTH lb (N) min	MINIMUM BURST STRENGTH psi (MPa)
A	0.30	250 (1110)	500 (3.4)
B	0.60	200 (890)	320 (2.2)
C	0.30	200 (890)	320 (2.2)
D	0.60	90 (400)	145 (1.0)
E	0.30	90 (400)	145 (1.0)

- D. Class F Geotextiles (Silt Fence) shall have a 50 lb/in. (8.8kN/m) minimum tensile strength and a 20 lb/in. (3.5kN/m) minimum tensile modulus when tested in conformance with D4595. The material shall also have a 0.3 gal/ft² (12.21/m²) per minute minimum flow rate and a 75 percent minimum filtering efficiency when tested in conformance with D 5141.
- E. The properties shall be determined as follows:

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TEST	METHOD
Apparent Opening Size	D 4751
Grab Tensile Strength	D 4632, Grab Test – 4 x 8 in. (100 x 200 mm) specimen, 1 x 2 in. (25 x 50 mm) clamps; 12 in. (300 mm)/minute strain rate both principal directions of geotextile.
Burst Strength	D 3786

Sewing of the geotextile will be allowed provided it conforms to the following:

- a) Seams shall be either "J" or "butterfly" type and shall utilize a lock stitch.
- b) Seams shall conform to the tensile strength requirements for the geotextile when tested across the seam.
- c) The thread for seaming shall be of equal or greater durability than the geotextile itself.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 2 Section 312300 "Excavating and Filling."

3.2 IDENTIFICATION

- A. Materials and their installation are specified in Division 2 Section 312300. Arrange for installation of green detectable warning tapes directly over piping and at outside edges of underground structures.

3.3 PIPING APPLICATIONS

- A. General: Include watertight, silttight, or soiltight joints, except where watertight or silttight joints are indicated.
- B. Refer to Part 2 of this Section for detailed specifications for pipe and fitting products listed below. Use pipe, fittings, and joining methods according to the following applications.
- C. High Density Polyethelene Pipe (HDPE), Hancor Blue Seal corrugated polyethylene pipe installed per manufacturers' specifications.
- D. Reinforced-concrete sewer pipe and fittings; rubber gaskets; and gasketed joints.
- E. Polyvinyl Chloride (PVC) pipe: ASTM D 3034, PVC, solvent-cemented, sewer pipe fittings; and solvent-cemented joints.

3.4 SPECIAL PIPE COUPLING AND FITTING APPLICATIONS

- A. Special Pipe Couplings: Use where indicated and where required to join piping and no other appropriate method is specified. Do not use instead of specified joining methods.

1. Use the following pipe couplings for nonpressure applications:

- a. Strait-pattern, sleeve type to join piping, of same size, with small difference in outside diameters.

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- b. Increaser/reducer-pattern, sleeve type to join piping of different sizes.
 - c. Gasket type to join piping of different sizes where annular space between smaller piping's outside diameter and larger piping's inside diameter permits installation.
 - d. Internal-expansion type to join piping with same inside diameter.
- B. Special Pipe Fittings: Use where indicated.
- 3.5 INSTALLATION, GENERAL**
- A. General Locations and Arrangements: Drawings (plans and details) indicate the general location and arrangement of underground drainage systems piping. Location and arrangement of piping layout take into account many design considerations. Install piping as indicated, to extent practical and in accordance with the requirements of the Charles County Specifications and in accordance with the pipe manufacturer's written instructions. Where installation details are not shown on the Drawings, installation shall be in accordance with the Charles County Standard Details.
 - B. Install piping beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's recommendations for use of lubricants, cements, and other installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.
 - C. Use manholes for changes in direction.
 - D. Use proper size increasers, reducers, and couplings, where different sizes or materials of pipes and fittings are connected. Reduction of the size of piping in the direction of flow is prohibited, except as indicated on the plans.
 - E. Install piping at constant slope between points and elevations indicated. Install straight piping runs at constant slope, not less than that specified, where slope is not indicated.
 - F. Extend piping and connect to building's storm drains, of sizes and in locations indicated. Terminate piping as indicated.
 - G. Install piping pitched down in direction of flow, at minimum slope of 1 percent (1:100) and 36-inch minimum cover, except where otherwise indicated.
- 3.6 PIPE JOINT CONSTRUCTION AND INSTALLATION**
- A. General: Join and install pipe and fittings according to the following.
 - B. Polyvinyl Chloride Schedule 40 Pipe (P.V.C. SCH40) Pipe and Fittings: Join and install in accordance with manufacturer's instructions.
 - C. Concrete Pipe and Fittings: Install according to ACPA "Concrete Pipe Handbook." Use the following seals:
 1. Round Pipe and Fittings: ASTM C 443 (ASTM C 443M), rubber gaskets.
 - D. Join piping made of different materials or dimensions with couplings made for this application. Use couplings that are compatible with and fit both systems' materials and dimensions.
- 3.7 MANHOLE INSTALLATION**

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- A. General: Install manholes, complete with accessories, as indicated.
- B. Form continuous concrete channels and benches between inlets and outlet, where indicated.
- C. Set tops of frames and covers flush with finished surface where manholes occur in pavements. Set tops 3 inches above finished surface elsewhere, except where otherwise indicated.
- D. Place precast concrete manhole sections as indicated, and install according to ASTM C 891.
 - 1. Provide rubber joint gasket complying with ASTM C 443, at joints of sections.
 - 2. Apply bituminous mastic coating at joints of sections.
- E. Construct cast-in-place manholes as indicated.

3.8 STORM DRAIN OUTFALL INSTALLATION

- A. Install concrete end sections as indicated.
- B. Construct rip-rap of broken stone, as indicated.

3.9 CONCRETE PLACEMENT

- A. Place cast-in-place concrete according to ACI 318, ACI 350R, and as indicated.

3.10 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.
- B. Set cleanout frames and covers in concrete paving with tops flush with surface of paving.
- C. Cleanouts located in paving shall have countersunk lids.

3.11 CLOSING ABANDONED DRAINAGE SYSTEMS

- A. Abandoned Piping: Close open ends of abandoned underground piping that is indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either of the following procedures:
 - 1. Close open ends of piping with at least 8-inch-thick brick masonry bulkheads.
 - 2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.
- B. Abandoned Structures: Excavate around structure as required and use either of the following procedures:
 - 1. Remove structure and close open ends of remaining piping.
 - 2. Remove top of structure down to at least 36 inches below final grade. Fill to within 12 inches of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.
 - 3. Backfill to grade according to Division 2 Section 312300 "Excavating and Filling."

3.12 FIELD QUALITY CONTROL

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- A. Clear interior of piping and structures of dirt and superfluous material as the work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.
 - 1. In large, accessible piping, brushes and brooms may be used for cleaning.
 - 2. Place plug in end of incomplete piping at end of day and whenever work stops.
 - 3. Flush piping between manholes and other structures, if required by authorities having jurisdiction, to remove collected debris.
- B. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of the Project.
 - 1. Submit separate reports for each system inspection.
 - 2. Defects requiring correction include the following:
 - a. Alignment: Less than full diameter of inside of pipe is visual between structures.
 - b. Deflection: Flexible piping with deflection that prevents passage of a ball or cylinder of a size not less than 92.5 percent of piping diameter.
 - c. Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.
 - e. Exfiltration: Water leakage from or around piping.
 - 3. Replace defective piping using new materials and repeat inspections until defects are within allowances specified.
 - 4. Reinspect and repeat procedures until results are satisfactory.
- C. Test new piping systems and parts of existing systems that have been altered, extended, or repaired for leaks and defects.
 - 1. Do not enclose, cover, or put into service before inspection and approval.
 - 2. Test completed piping systems according to authorities having jurisdiction.
 - 3. Schedule tests, and their inspections by authorities having jurisdiction, with at least 24 hours advance notice.
 - 4. Submit separate reports for each test.
 - 5. Where authorities having jurisdiction do not have published procedures, perform tests as follows:
 - a. Storm Drainage: Perform hydrostatic test.
 - (1) Allowable leakage is a maximum of 200 gallons per inch nominal pipe size, for every mile of pipe, during a 24-hour period.
 - (2) Close openings in system and fill with water.
 - (3) Purge air and refill with water.

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- (4) Disconnect water supply.
 - (5) Test and inspect joints for leaks.
 - (6) Option: Test ductile-iron piping according to AWWA C600, Section 4 "Hydrostatic Testing." Use test pressure of at least 5 psig.
 - (7) Option: Test concrete piping according to ASTM C 969.
 - (8) Option: Test concrete arch piping and elliptical piping according to authorities having jurisdiction.
- b. Storm Drainage: Perform hydrostatic test. Close openings in system and fill with water to not less than 10-foot head of water. Disconnect water supply. Water level must not drop for 15 minutes. Inspect joints for leaks.
- (1) Option: Test concrete arch piping and elliptical piping according to authorities having jurisdiction.
- c. Storm Drainage: Perform air test according to UNI-B-6.
- (1) Option: Test round concrete piping, 24 inches and smaller, according to ASTM C 924.
 - (2) Option: Test concrete arch piping and elliptical piping according to authorities having jurisdiction.
6. Manholes: Perform hydraulic test according to ASTM C 969.
 7. Leaks and loss in test pressure constitute defects that must be repaired.
 8. Replace leaking piping using new materials and repeat testing until leakage is within allowances specified.

END OF SECTION 33 34 00