FIRE STATION #6

Greeley, Colorado

75% Design Documents
Specification
Project Manual

VOLUME TWO

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SECTION 211000 - FIRE SUPPRESSION SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Refer to Division 22, Section 221000 – Pipes, Valves and Piping Specialties.

1.02 DESCRIPTION OF WORK

A. Furnish and install a complete automatic fire sprinkler system as indicated below.

1. Fully fire sprinkler the entire building.

B. The work shall include but not be limited to the following items:

1. System Design Requirements.
2. Sprinkler System.
3. Fire Department Connections.
4. Inspectors Test and Drain Assembly.
5. Drain Terminations.

1.03 SUBMITTALS

A. See Section 013000 - Administrative Requirements for Submittal Procedures.

B. Product Data: Submit product data for the following items:

1. Pipe, fittings, hangers, attachments devices, and valves.
2. Sprinkler heads and escutcheons.
3. Specialty valves and devices.
4. Alarms and connecting devices.
5. Flow switches.
6. Siamese fire department connections.
7. Inspections Test and Drain Assembly.
8. Fire Flow Test Results.

C. Shop Drawings: Submit shop drawings for the following items:

1. Engineered fabrication drawings shall be in a currently supported version of Revit software format (3D modeling) and shall show main and line elevations, sizes, and routing.
2. Drawings showing lights, registers, grilles, diffusers, heat detection devices, ceiling grids, beams, joists, trusses and other items of possible interference with proper function or routing of the system and component devices such as access panels, clerestories, display structures, skylights, atriums, etc.

3. Hydronic calculations prepared in a form with appropriate information as required and acceptable to all reviewing and jurisdictional agencies. Include certified flow test data with calculations.
4. All drawings and calculations shall be reviewed and accepted by the jurisdictional fire department, building department, fire marshal, and the insurance carrier or insurance reviewing authority prior to submitting to the Architect. Indication of review and acceptance by all agencies, as appropriate, shall be certified by name of reviewer, agency, and date affixed to the plans or reproducibles submitted to the Architect.
5. Alarms, devices, monitors and all electrical wiring diagrams
6. Partial submittals shall not be acceptable.
7. Equipment submittals shall contain annotated descriptive data to show the specific model, type and size of each item the Designer and Installer proposes to furnish. Catalog cut sheets shall be submitted in a suitable folder or binder and indexed referencing the applicable specification sections. Unclear or partial reproductions of manufacturer's original catalog cuts or descriptive data shall not be accepted. Each item supplied shall be clearly identified on each sheet. Where the submittal material describes items, in addition to the items being submitted, the additional items shall be crossed out and the submittal item shall be identified. Submit proof of compatibility for equipment components required to be approved as a system.
8. Review by the Engineer shall not relieve the Designer and Installer from full compliance with requirements of the contract documents, codes, and standards.
9. Submit detailed shop drawings including a riser diagram, stamped and signed hydraulic calculations, equipment data sheet submittals and employee certification in accordance with NFPA #13.
10. Submit anchoring details and calculations.

D. Certificate of Installation: Submit certificate upon completion of fire protection piping work which indicates that work has been tested in accordance with NFPA 13 and that system is operational, complete, and has no defects.

E. Record Drawings: At project closeout, submit record drawings of installed fire protection piping and products in accordance with requirements of Section 017800.

F. Maintenance Data: Submit maintenance data and parts lists for fire protection materials and products. Include this data, product data, shop drawings, approval drawings, approval calculations, certificate of installation, and record drawings in maintenance manual in accordance with requirements of Section 017800 – Closeout Submittals.

1.04 QUALITY ASSURANCE

A. Designer and Installer's Qualifications: Firms regularly engaged in the design and installation of fire protection systems, of types, materials, and sizes required, which have been in satisfactory use in similar service for not less than 5 years.

1. The design of the fire protection systems including hydraulic calculations shall be stamped and signed by a registered P.E. or a NICET level IV or higher. Said professionals shall be experienced in fire protection, thoroughly familiar with and experienced in this type of installation.
2. The owner's representative, Engineer, and AHJ reserve the right to request proof of qualifications.

3. No design related work shall be subcontracted or performed by persons other than bona fide employees working solely for the Designer and Installer. Any exception shall be pre-approved by the owner, in writing.
4. The entire fire protection system project including design, calculation, installation, and testing, excluding prefabrication, shall be bid by a single firm which has the capabilities to perform all of the work required under this standard. No installation work shall be subcontracted without prior permission in writing from the Owner/Architect/Engineer.
5. Shall have an emergency service capability for response to emergency conditions.
6. Shall have an established office within one hundred (100) miles of the project which maintains a full complement of spare parts, tools and equipment for the specific project and type of system.
7. Welders shall comply with the requirements of AWS D10.9, "Specifications of Qualifications of Welding Procedures and Welders for Piping and Tubing, Level AR-3."
8. Job foremen shall be trained for the installation and operation of each type of system and possess documentation of qualifications and training. Foremen shall have a minimum of three (3) years of successful installation experience on projects with fire protection systems similar in scope and nature to that required for the project.

B. Codes and Standards:

1. NFPA Compliance: Install fire protection systems in accordance with NFPA as applicable.
2. UL Compliance: Provide fire protection products in accordance with UL standards; provide UL label on each product.
3. Fire Department/Marshal Compliance: Install fire protection systems in accordance with local regulations of fire department or fire marshal.
4. Screw Thread Connections: Comply with local Fire Department/Marshal regulations for sizes, threading and arrangement of connections for fire department equipment to standpipe system.

1.05 SYSTEM DESIGN REQUIREMENTS

A. Verify requirements with Jurisdictional authorities, i.e.: Insurance Co. or Underwriter, Fire Department or Marshal, or Building Departments. Provide system complete, functional and acceptable to Jurisdictions without penalty of any type to the insurance premium rate.

B. System shall be installed hydraulically calculated per NFPA #13, 14, & 20.

C. Sprinkler Occupancy Hazard Conditions:

1. Automobile Parking Areas: **Ordinary Hazard, Group 1**.
2. Building Service Areas: **Ordinary Hazard, Group 1**.
3. Electrical Equipment Rooms: **Ordinary Hazard, Group 1**.
4. General Storage Areas: **Ordinary Hazard, Group 1**.
5. Mechanical Equipment Rooms: **Ordinary Hazard, Group 1**.
6. Office and Public Areas: **Light Hazard**.

D. Minimum Density for Automatic-Sprinkler Piping Design:

1. Light Hazard Occupancy: **0.10 gpm over 1,500 SF**.

2. Ordinary Hazard, Group 1 Occupancy: **0.15 gpm over 1,500 SF**.

E. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and Section 220000.

F. System shall be designed to provide sprinkler heads at ¼ points in 2'x4' lay-in ceiling tiles in a uniform pattern, centered in 2' direction, ¼ points in 4' direction. All heads shall be centered in 2'x2' lay in ceiling tiles.

G. All calculations shall include flow test results. Flow tests shall be performed by this Designer and Installer and verified by the Fire Department, Architect, and Engineer. Prior flow tests on file with jurisdictional agencies may be used in lieu of new flow tests only when previous test has been made within 3 months of project start date.

H. Designer shall use 85% of flow test pressure data as the base in performance of the Project Calculations.

I. Six Copies of Hydraulic Calculations and Drawings shall be submitted for review. Drawings shall show hydraulic reference points, hydraulically most remote areas clearly shown, and proof by example that area shown is in fact the hydraulically most remote.

J. Area and densities shall conform to NFPA #13 or jurisdictional authorities requirements.

K. Include all lines as center to center of fittings, not cut lengths, include all fittings.

L. Sprinkler system shall be calculated from the flow test elevation to the highest sprinkler head.

M. Provide all trim and accessories, inlets, alarms, switches, and valves required.

N. Provide bracing, restraining, thrust blocks, rods, anchors, cathodic protection, and plastic pipe wrap as required.

O. Water supply flow test(s) shall be conducted in strict accordance with NFPA #13 and NFPA #291.

P. Hydraulic calculation submittals shall clearly define and annotate all devices which will cause friction loss with equivalent lengths of pipe. This includes vane type electric water flow switches (assume 10 feet of equivalent length of pipe).

Q. The Designer and Installer shall coordinate that all piping and fire sprinkler heads are located within a heated space with the HVAC Contractor and HVAC Drawings. Provide necessary dry type systems and heads in all non-heated spaces.

R. No fire sprinkler piping in electrical rooms other than piping serving the room. No piping over electrical or control panels.

S. At system drains terminating at the exterior of the building, Designer and Installer shall provide termination to concrete splash block or riprap which drains to a pervious surface. All termination points shall be coordinated with Architect or Engineer.

1.06 SITE OBSERVATION REPORTS

A. During the construction period the Engineer may issue periodic site observation reports. The Designer and Installer shall immediately address the issues and provide a written response identifying the “Responsible Contractor,” “Date,” “Corrective Action Taken,” and “Recommendations.”

B. The written response must be returned to the Architect no later than (5) working days after receipt of the site observation report.

1.07 PROJECT CONDITIONS

A. Installer shall not fabricate or install any piping until they have assured themselves that the piping can be run as contemplated in cooperation with Contractors of other Divisions of the Work and the physical constraints of the Structural and Architectural Work.

B. Designer and Installer shall participate in coordination drawings as indicated in both 22 0500 and 23 0500 “Scope of Work”.

1.08 WARRANTY

A. Provide original copies of all warranties and extended warranties for specific equipment where specified and in accordance with Section 220500.

PART 2 - PRODUCTS

2.01 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 fire protection systems. Where more than one type of materials or products are indicated, selection is Installer's option.

2.02 BASIC IDENTIFICATION

A. General: Provide identification complying with Section 220553, "Plumbing Identification" in accordance with the following listing:

1. Fire Protection Piping: Pipe markers.
2. Fire Protection Valves: Valve tags.
3. Fire Protection Signs: Provide the following signs:

   a. At each sprinkler valve, sign indicating what portion of system valve controls.
   b. At each outside alarm device, sign indicating what authority to call if device is activated.

2.03 BASIC PIPES AND PIPE FITTINGS

A. General: Provide pipes and pipe fittings in accordance with the following:

B. Underground Piping:

1. General:

a. Pipe: Cast iron, 250 psi or ductile iron Class II, 250 psi, AWWA C151.
b. Fittings: Cast iron and ductile iron pipe fittings shall correspond to pipe in material, Class and ASTM designation.
c. Joints: Mechanical joint type, complete with set screw retaining glands.

2. Schedule:

Pipe Size (Inches)	Type Cast Iron	Maximum Bury (Feet)	Wall Thickness (Inches)
4 thru 8	18/40	16	0.32 thru 0.44
10 thru 12	21/45	16	0.48 thru 0.68

3. Rotatable Fittings:

a. Provide for all service risers and valves, MJ x PE or rotatable MJ gland tees and connecting pieces to provide plumb and true valve and service riser settings.

4. Thrust Blocks - Tie Rods:

a. Provide 3000 lb. type II concrete thrust blocks with soil contact area based on not more than 2000 psf horizontal soil bearing quality, and enveloping 1/2 of pipe, fitting, or valve. Provide saddle reinforcing as required.
b. Provide 1/2" minimum machine thread rods and clamps on all service entries from last joint underground to riser elbow or wall entry and to first joint in the building. All rods, clamps, and bolts double coated with "ZRC" brand cold galvanizing coating after installation and draw up. Provide 1 coat of coal tar coating over galvanizing.

1) NOTE: Clamps and rods do not preclude the requirements for thrust blocks.

c. Provide 8 mil thick minimum polyethylene pipe encasement sleeve, overlap at joints and seal joint with 2" wide minimum polyethylene tape triple wrapped and extending at least 6" both ways beyond joint seam or provide machine wrapped Scotchwrap #51 PVC tape with 50% overlap wrap on pipe primed with Scotchwrap primer. Double wrap all fittings to 6" beyond fitting onto pipe. Provide primer on fittings, bolts, and nuts prior to wrapping.

C. Interior Piping:

1. Interior and Exterior Above-ground Piping:

a. Pipe and Joints (Piping System Allowed):

1) U.S. Manufactured, Schedule 40 black steel threaded or welded and/or Schedule 10 roll grooved conforming to ASTM A-53.
2) Provide galvanized steel piping and fittings on all dry pipe systems.
3) Option to provide light wall conforming to ASTM A-795 equal to Dyna-Thread, or replacement Schedule 10 equal to American Tube Dyna-Flow ASTM-795. All threaded piping shall meet a threaded CRR equal to 1.00 or better, 300 psi max. system pressures.
4) All pipe shall conform to NFPA #13, Chapter 3 and shall be UL/FM approved. Schedule 5 piping is not allowed.

b. Fittings:

1) Threaded cast iron Class 125, 300 psi service and in accordance with developed system pressures, conforming to ANSI B16.4. Threaded malleable iron Class 150, 175 psi service and in accordance with developed system pressures, conforming to ANSI B16.3. Ductile iron Class 150, 500 psi service and in accordance with developed system pressure, conforming to ASTM A-536-Grade 65-45-12, ANSI B16.3, and ANSI B-1.20.1.
2) Weld type fittings (schedule 40 pipe only): Buttweld conforming to ANSI B16.9. Flanges conforming to ANSI B16.25. Socket weld conforming to ANSI B16.11. All welds by certified welder in accordance with Section 221000.
3) Grooved fittings shall conform to ASTM-A47 (malleable), ASTM 536 (ductile), or ASTM-106 GRB (forged steel), ASTM A-53 type E, F, or S GRB (nipples), ANSI B-16.5 or B16.1 cast iron and carbon steel flanges.
4) Approved manufacturers:

a) Victaulic (Grooved Fittings).
b) Grinnell (Grooved Fittings).
c) Anvil (Grooved, Welded & Threaded Fittings).
d) Ward (Threaded Fittings).
e) Weldbend (Welded Fittings).

D. Valves:

1. All valves are to be indicating type.
2. All valves U.L. listed, F.M. approved.
3. Refer to Section 221000 for valve Specifications.

E. Hangers:

1. All hangers, attachments and components U.L. listed, F.M. approved.
2. Refer to Section 221000 for Specifications and restrictions for hanger systems. Where specification is more stringent, these requirements will apply.
3. Permission to use anchoring system utilizing powder driven studs <u>must</u> <u>be</u> obtained from the Structural Engineer <u>prior</u> <u>to</u> submitting pricing or bids.

F. Backflow Preventers:

1. Provide backflow preventer assemblies in fire service as required by local water department.

2. Backflow preventers shall be as required and shall be U.L. and F.M. listed for fire protection service. OS&Y gate valves shall be furnished as part of each assembly.

2.04 FIRE PROTECTION SPECIALTIES

A. General: Provide fire protection specialties, UL-listed, in accordance with the following listing. Provide sizes and types which mate and match piping and equipment connections.

B. Water Flow and Pressure Switches:

1. Paddle Type Flow Switch, for pipe sizes 2" thru 8", retard adjustment from 0 to 70 seconds instantly recycling.

   a. Manufacturer: Notifier
   b. Model: WFDT with dual contacts

2. Paddle Type Flow Switch for pipe sizes 1", 1-1/4" and 1-1/2", 10 second delay.

   a. Manufacturer: McDonnell
   b. Model: FS4-3F with dual contacts

3. Coordinate voltage with Fire Alarm Contractor.

C. Supervisory Switches:

1. Gate, OS&Y, and other exposed rising stem type valves:

   a. Manufacturer: Notifier
   b. Model: NGV or SGV

2. Coordinate voltage with Fire Alarm Contractor.

D. Alarms:

1. Exterior Audible and Visual Alarm:

   a. Manufacturer: Notifier Wheelock
   b. Model: Surface
   c. Unit: 7004T
   d. Box: WBB

2. Provide with flasher, surface mounting in weather proof enclosure.
3. Coordinate voltage with Fire Alarm Contractor.

E. Acceptable Manufacturers:

1. Guardian Inc.
2. Notifier Co.
3. Potter Signal, Inc.
4. Simplex Co.
5. System Sensor.

2.05 AUTOMATIC SPRINKLERS

A. General: Provide automatic sprinklers in accordance with the following listing.

1. Provide off-white finished plate for concealed heads in all finished ceilings.
2. Provide brass upright/pendant and sidewall heads in all exposed ceiling areas and unfinished areas.
3. Provide fire sprinkler protection cages on sprinkler heads installed less than 7'-6" above the finished floor.
4. For High Volume Low Speed (HVLS) Fans 6’ or larger, provide (4) fire sprinkler heads centered around fan and located a minimum of 3’ above fan.
5. Flexible sprinkler head assemblies are an acceptable option.

B. Sprinkler Heads: Provide quick response type throughout project. An option will be to provide either standard or extended coverage heads.

C. Flexible Sprinkler Head Assemblies:

1. Flexible stainless-steel hose that attaches to sprinkler heads
2. Flexible connectors shall have materials suitable for system fluid. Include 200-psig maximum working pressure rating.
3. Stainless Steel Hose/Steel Pipe, Flexible Connectors: 304 stainless steel, fully welded non-mechanical fittings, braided, leak tested with minimum 1” true bore internal corrugated hose diameter. Minimum bend radius: 12”.
4. Flexible Hose Attachment: Removable hub type with set screw.

D. Sprinkler Head Cabinets:

1. Provide cabinet complete with appropriate heads, wrench and mounting per NFPA.
2. Acceptable Fire Sprinkler Head Manufacturers: Subject to compliance with requirements, provide automatic sprinklers of one of the following:

    a. Central.
    b. Globe Inc.
    c. Grinnell Fire Protection Systems Co. Inc.
    d. Reliable Corp.
    e. Tyco.
    f. Viking Inc.

3. Acceptable Flexible Head Manufacturers:

    a. Flex Head.
    b. Viking, Inc.

2.06 FIRE DEPARTMENT INLET (SUPPLY) CONNECTION

A. Provide siamese connections of sizes, styles and patterns required, individual clappers for each inlet, caps and chains, and finish specified.

B. Schedule:

Style	Wall Flush
Manufacturer:	Potter Roemer
Model:	2-way No. 5021
Finish:	Polished Chrome

1. Provide index plates. Index plates shall read "Auto Spkr".

C. Acceptable Manufacturer:

1. Croker-Standard Div.
2. Elkhart Brass Mfg. Co.
3. Guardian Inc.
4. Potter-Roemer, Inc.

2.07 INSPECTOR'S TEST AND DRAIN ASSEMBLY

A. Provide AGF #1011A, test and drain assembly, U.L. and F.M. approved, 300 PSI rated, lockable, with piped pressure relief valve.

PART 3 - EXECUTION

3.01 PREPARATION AND INSPECTION

A. Field Measurements: Verify all dimensions before proceeding with the work. Obtain field measurements for work required to be accurately fitted to other construction. Be responsible for the accuracy of such measurements and precise fitting and assembly of finished work. Prefabrication of systems is done at this Designer and Installer's own risk.

B. Coordination: Coordinate all work and placement of components with other trades, be responsible for complete coordination of design and field installation, (remedial field work will be required to eliminate conflicts) and provide an acceptable finished product. Removal of piping and heads will be required at Designer and Installer's expense if field coordination does not take place.

3.02 INSTALLATION

A. General: Provide a complete operable system designed and installed in accordance with applicable local, state, federal and jurisdictional codes, enforcement agencies and insurance rating or underwriting agencies.

B. All systems shall be drainable with proper drainage devices, and drain terminations either to exterior of building or to properly sized receptacles within building. The Installer shall route drainage per NFPA and coordinate locations with Architect/Engineer prior to installation.

C. All systems shall be supported and braced for conformance to proper and applicable standards.

D. Care shall be taken with chrome plated or other polished finish components so that marring does not occur to the finish, and installation provides for a uniform pattern and true installation.

E. Install Sprinkler heads on a true axis line in both directions a maximum deviation of 1/2 inch plus or minus. Any heads exceeding the maximum tolerance are to be removed and re-installed by the contractor at no additional cost.

F. Where piping passes thru masonry units or concrete walls or floors or other building construction, sleeves must be used. Where exposed piping passes thru finished work, chrome, plated or other finish acceptable to architect, split wall plates or escutcheons shall be installed to fit snugly around piping. Where rated walls are penetrated, approved safing shall be provided at each hole to assure effectiveness of construction as a fire stop.

G. All openings for piping should be anticipated and coordinated. Indicate such openings on the shop drawings. Any additional cutting of openings must have the written approval of the Architect.

H. Designer and Installer shall complete the automatic fire sprinkler ready for operation, in all respects, as soon as possible. When system is complete and ready for continuous operation, activate the system for its intended use. After system has been activated for continuous use, water charges, if any will be paid for by the Owner.

I. Provide identification sign of the standard design adopted by the Automatic Sprinkler Industry, attaching same to all valves, drains, test connections, etc., with chain around body of valve in such a way that the sign cannot be removed without opening link.

J. Provide hydraulic placard indicating the location of calculated system, the discharge density over designed area of discharge, including gallons per minute and residual pressure demand at the base of riser. Place this sign at the system control valve.

K. Use no face bushings.

L. Furnish wiring requirements to Division 26 Contractor for interior alarm items furnished in this Section.

M. Designer and Installer shall coordinate piping elevation with other trades prior to installation. All other trades shall have right-of-way over fire protection piping if not coordinated.

3.03 FIELD QUALITY CONTROL

A. Sprinkler Piping Flushing: Prior to connecting sprinkler risers, flush water feed mains, lead-in connections and control portions of sprinkler piping. After fire sprinkler piping installation has been completed and before piping is placed in service, flush entire sprinkler system, as required to remove foreign substances, under pressure as specified in NFPA 13. Continue flushing until water is clear.

B. Hydrostatic Testing: After flushing system, test fire sprinkler piping hydrostatically, for period of 2 hours, at not less than 200 psi or at 50 psi in excess of maximum static pressure when maximum static pressure is in excess of 150 psi. check system for leakage of joints. Measure hydrostatic pressure at low point of each system or zone being tested.

C. Repair or replace piping system as required to eliminate leakage in accordance with NFPA standards for "little or no leakage" and retest as specified to demonstrate compliance.

3.04 ADJUSTING AND CLEANING

A. Cleaning and Inspecting: Clean and inspect fire protection systems in accordance with requirements of Section 221000 – Pipes, Valves and Pipe Fittings.

3.05 EXTRA STOCK

A. Heads: For each style and temperature range required, furnish additional sprinkler heads, amounting to one unit for every 100 installed units, but not less than 5 units of each.

B. Wrenches: Furnish 2 spanner wrenches for each type and size of valve connection and fire hose coupling.

1. Obtain receipt from Owner that extra stock has been received.

3.06 CERTIFICATE OF COMPLETION

A. Obtain certificate of compliance and completion for jurisdictional agencies, as applicable and present to Owner.

END OF SECTION 211000

SECTION 220500 – COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.01 DESCRIPTION OF SYSTEMS

A. Division 22 includes but is not limited to:

1. Section 220500 – Common Work Results for Plumbing.
2. Section 220553 – Plumbing Identification.
3. Section 220700 – Plumbing Insulation.
4. Section 221000 – Pipe, Valves and Pipe Specialties.
5. Section 222000 – Plumbing Systems.

1.02 DESCRIPTION OF WORK

A. Work Included: Unless specified otherwise, provide all supervision, labor, materials, transportation, equipment, hauling, and services necessary for a complete and operational mechanical system. Provide all incidental items such as offsets, fittings, etc. required as part of the work even though not specifically shown on Contract Drawings or Specifications.

B. Requests for Information: See Section 012000 – Price & Payment Procedures, for required research of Contract Documents and subsequent documentation of noted issues through requests for information.

C. Types of mechanical related work specified in this section include the following:

1. Motors.
2. Starters.
3. Access Doors.
4. Excavation.
5. Cutting and Patching.

1.03 SUBMITTALS

A. Provide the following submittals:

1. Access Doors.

1.04 UTILITIES, EXTENSIONS, CONNECTIONS AND FEES FOR WATER, SEWER AND GAS

A. Provide all services within the building to a point five (5) feet outside of building. Provide permanent marker at grade for other contractors' location reference for connection purposes.

B. Provide all building services and connections to site utilities, as indicated on Drawings.

C. In the event that the serving utility (gas) company installs their own taps, service, meters, etc., all costs imposed by this action shall be paid for by the Owner. Extensions from termination points to connection with building services and systems will be the responsibility of the Division 22 Contractor.

1.05 REFERENCES

A. See Section 014000 – References and Standards.

B. For products or workmanship specified by Association, Trade or Federal Standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.

C. The date of the standard is that which is in effect as of the date of the Contract Documents, except when a specific date is specified.

1.06 QUALITY CONTROL

A. See Section 014000 – Quality Requirements for general quality control requirements.

B. Materials and apparatus required for the plumbing scope of work shall be new and of first-class quality. Delivered, erected, connected and finished in every detail, and selected and arranged so as to fit properly into the building spaces.

C. Unless otherwise specifically indicated, equipment and materials shall be installed in accordance with the recommendations of the manufacturer. This includes the performance of tests as recommended by the manufacturer.

1.07 EXAMINATION OF CONTRACT DRAWINGS AND SPECIFICATIONS

A. The Plumbing Drawings show the general arrangement of piping, plumbing equipment, and appurtenances, and shall be followed as closely as actual building construction and the work of other trades will permit.

B. The Architectural and Structural Drawings shall be considered part of the plumbing work insofar as these Drawings furnish this Division with information relating to design and construction of the building.

C. Field verify building dimensions governing plumbing work. Do not scale the Plumbing Drawings for dimensions.

D. The Plumbing Contractor shall request of the Test and Balance (TAB) Contractor an early review of the Contract Documents for the purpose of identifying where proper balancing cannot be achieved. The report requirements are specified in Division 23, Temperature Controls section, “Submittals.” Forward a copy of the report to the Mechanical Engineer for review. The Plumbing Contractor shall modify the system as recommended by the TAB Contractor or refer unresolved issues to the Mechanical Engineer for resolution prior to ordering of equipment. Unresolved balancing issues from untimely or incomplete application of these requirements will be the responsibility of the Plumbing Contractor to correct.

E. Discrepancies:

1. Examine Drawings and Specifications for other parts of the work, and if any discrepancies occur between the drawings for the work of this Division and the drawings for the work of others, report such discrepancies as a request for information following the procedure outlined in Section 012000.
2. Should there be a conflict in dimensions or locations between Plumbing Drawings and/or other Drawings, report such discrepancies as a request for information following the procedure outlined in Section 012000.

1.08 REGULATORY REQUIREMENTS

A. See Section 014100 – Regulatory Requirements, for applicable codes and regulations in addition to the following.

1. 2015 Current International Plumbing Code
2. 2015 Current International Fuel Gas Code
3. 2015 Current International Fire Code
4. 2015 Current International Energy Code

1.09 COORDINATION

A. See Section 013114 – Facility Services Coordination, for coordination requirements and procedures between all applicable construction trades.

B. Before purchase, fabrication, or installation of plumbing components, determine if the installation will properly fit and can be installed as contemplated without interference with structural elements or the work of other trades.

C. Locations of pipes, ducts, switches, panels, equipment, and fixtures, shall be adjusted to accommodate the work or interferences anticipated and encountered. Determine the exact route and location of each pipe and duct prior to fabrication.

D. Right of Way: Lines which pitch shall have the right-of-way over those which do not pitch. Lines whose elevations cannot be changed shall have right-of-way over lines whose elevations can be changed.

E. Offsets, transitions and changes in direction of pipes and ducts shall be made as required to maintain proper head room and pitch of sloping lines whether or not indicated on the Drawings.

F. Where major conflicts occur, contractor shall rely upon the Architect/Engineer to make final decision regarding priority of right-of-way. Prior to installation or removal of components in conflict, report any such conflicts as a request for information following the procedure outlined in Section 012000.

G. When directed by the Architect/Engineer, submit Coordination Drawings showing interrelationship of various portions of work and work of other trades. Failure to properly coordinate may result in removal and relocation at expense to the Contractor.

H. Coordination Drawings for Acoustical and Drywall Ceilings, Plumbing, Fire Protection, HVAC and Electrical shall be provided in accordance with requirements listed in Section 013114 – Facility Services Coordination.

I. Coordination Drawings for Acoustical and Drywall Ceilings, Plumbing, Fire Protection, HVAC and Electrical:

1. Coordination Drawings are required for the trades noted above. The HVAC contractor shall prepare reproducible Coordination Layout and Installation Drawings (at least ¼" scale or as approved by the Architect) for resolution of interferences and conflicts with other trades.
2. The Plumbing, Fire Protection and Electrical Contractors, as well as acoustical and drywall ceiling contractors, are required to superimpose their Shop Drawings on the HVAC Drawings and verify layout and elevations to eliminate conflicts. Any conflicts shall be highlighted and these Drawings shall be forwarded to the Architect for resolution. Priority shall be given to "gravity" systems above the ceiling. Each trade shall initial acknowledgement that the proceeding has been completed. No fabrication of ductwork, fire protection, or other prefabricated systems shall begin until these Coordination Drawings have been completed and reviewed by the General Contractor and Architect/Engineers. Any Subcontractor that fabricates and installs items above the ceiling before the Coordinated Drawings are reviewed and conflicts resolved shall do so at their own risk, and be responsible to relocate said equipment in the event conflicts arise, at no cost to the Owner.
3. Additionally, all trades shall show the proposed location of access panels (for maintenance) in "hard" ceilings for access to HVAC boxes, control valves, fire damper motors, plumbing valves, fire protection drains, valves, light fixture remote ballasts, ceiling hung equipment, etc., for coordination with the reflected ceiling plans. Indicate on same Drawings the location of access panels in walls as well as location of plumbing cleanouts.
4. Upon Architect/Engineer completion of the review of the Coordination Drawings, the Design Team, General Contractor and Subcontractors shall conduct a pre-installation coordination meeting for all "fit-up" above ceilings. No ceiling shall be lowered without the expressed approval of the Owner and the Architect.

J. Coordinate all cutting & patching, provide per Section 017000.

K. Utility Interruptions: Coordinate mechanical utility interruptions with the general contractor per Section 017000 – Execution & Closeout Requirements.

1.10 COMMISSIONING

A. Division 22 is responsible to participate in the commissioning process. See Section 019113 – General Commissioning Requirements. The commissioning process and contractor responsibilities are described in these sections. Plumbing contractor, sub-contractors and manufacturers equipment start-ups to comply with these sections and provide coordination with the commissioning agent as required.

1.11 PROJECT CONDITIONS

A. Accessibility:

1. Contractor shall be responsible for the sufficiency of the size of shafts and chases and the adequate clearance in double partitions and hung ceilings for proper installation of work. Such spaces and clearances shall be kept to the minimum size required.
2. Locate all equipment which must be serviced, operated, or maintained in fully accessible positions. Furnish access doors for this purpose. Minor deviations from Drawings may be allowed to provide for better accessibility. Any changes shall be approved by the Architect prior to making the change.
3. Determine the exact locations of access doors. Locations of these doors shall be submitted in sufficient time to be installed in the normal course of work.
4. Demonstration of access will be required prior to project completion. The contractor is responsible for providing reasonable and safe access for all system components. Plumbing Contractor to demonstrate access and serviceability of all equipment to Owner.

B. Fabrication: Before installing and/or fabricating any lines of piping or ductwork the Contractor shall assure himself that they can be run as contemplated in cooperation with Contractors of other Divisions of the Work and the physical constraints of the Structural and Architectural Work.

C. Freeze Protection: Do not run pipes in outside walls, or locations where freezing may occur. Piping next to outside walls shall be in furred spaces with insulation between the piping and the outside wall. Insulation of piping shall not be considered freeze protection.

D. Scaffolding, Rigging and Hoisting: Provide scaffolding, rigging, hoisting and services necessary for erection and delivery into the premises of any equipment and apparatus furnished. Remove same from premises when no longer required.

1.12 SUBMITTALS

A. See Section 013000 – Administrative Requirements, for submittal procedures applicable to all sections in Division 22.

B. The review comments of the Architect and/or Engineer do not in any case supersede the Drawings and Specifications, and shall not relieve the Contractor from responsibility for deviations from the Drawings or Specifications unless the Contractor has called to the attention of the Architect and/or Engineer, in writing, such deviations at the time of submission, nor shall it relieve the Contractor from responsibility for errors of any sort in the items submitted.

C. Deviations: It is the contractor's responsibility to indicate deviations from the Plans And Specifications. Approval shall not be considered acceptance of the deviation unless it has been explicitly indicated.

1.13 SEISMIC RESTRAINT PLAN SUBMITTAL:

A. The Plumbing Contractor shall provide a vibration and seismic restraint plan for projects designated a Seismic Design Category C (with a seismic importance factor greater than 1.0), D,

E, or F as found on the structural drawings. The plan shall include stamped and signed (engineer with minimum of 5 years of experience) drawings for the state in which the project is located, details, equipment cutsheets, and analysis from one of the acceptable equipment manufacturers listed below for the entire project scope. The Plumbing Contractor will provide the selected equipment manufacturer with a copy of the drawings, specifications, soils reports and any other pertinent information necessary to perform the vibration and seismic restraint analysis per pertinent codes.

B. Acceptable Manufacturers:

1. Mason Industries, Inc.
2. Kinetics Noise Control, Inc.
3. M. W. Sausse & Co., Inc.
4. Amber/ Booth, a VMC Company
5. Vibro Acoustics

1.14 FIELD REPORTS

A. During the construction period the Engineer may issue periodic field reports. The contractor shall immediately address the issues and provide a written response.

B. The written response must be returned to the Architect no later than (5) working days after receipt of the site observation report.

1.15 PRODUCT OPTIONS AND SUBSTITUTIONS

A. Substitutions: See Section 016000 – Product Requirements for substitution procedures applicable to all products specified in Division 22.

B. When alternate or substitute materials and equipment are used, Contractor will be responsible for space requirement, configurations, performance, changes in bases, supports, structural members and opening in structure, electrical changes and other apparatus and trades that may be affected by their use. Contractor shall provide drawings for alternate/substitute equipment in detail equal to the Construction Documents.

1.16 PROJECT RECORD DOCUMENTS

A. See Section 017800 – Closeout Submittals for submittal requirements and procedures.

1.17 ELECTRIC WIRING AND SAFETY DEVICE WORK AND MATERIAL RESPONSIBILITIES

A. Unless otherwise indicated, all mechanical equipment motors and controls shall be furnished, set in place, and wired in accordance with the following schedule: PD = Plumbing Division, MD = Mechanical Divisions, ED = Electrical Division, FD = Fire Protection Division, TD = Temperature Control Division, I = Installer of equipment requiring electrical service.

B. Note: If Temperature Control Division is a subcontract to the HVAC Contractor, both MD and TD shall fall under the responsibility of MD. If no Temperature Control Contractor is under contract, Mechanical Division shall assume all Temperature Control responsibilities.

	Furnished Under	Set In Place or Mounted Under	Power Wired & Connected Under	Control Wired & Connected Under
1. Other Equipment Motors/Starters	I	I	ED	I
2. Plumbing Equipment Motors	PD	PD	ED	TD
3. Control Wiring Regardless of Voltage	TD	TD	TD See footnote 1	TD
4. Control Components: Control Relays, Control Transformers,	TD	TD	TD See footnote 1	TD
5. Thermowells in Piping	TD	PD	--	--
6. Fire Protection (Exterior horn & light)	FD	ED	ED	ED
7. Fire Protection (Tamper & flow switch)	FD	FD	ED	ED See footnote 2
8. Manual Operating Switches	PD	PD	ED	-- See footnote 3
9. Fused and Unfused Disconnect Switches & Thermal Overload Switches	ED See footnote 4	ED See footnote 4	ED	--
10. Contactors	ED	ED	ED	ED
11. Water Heater Controls	PD	PD	TD See footnote 1	TD
12. Remote Disconnect Switches for Boiler (Heating, Domestic HW) Controls per ASME-CSD-1.	TD	TD See footnote 5	ED See footnote 6	TD

1. Footnote 1: It is the intention of this specification for all conduit and wiring which connects to control equipment or provides controls to mechanical equipment to be provided by the Temperature Control Contractor. Other portions of the specification which may be in conflict with this concept shall be brought to the attention of the engineer for clarification prior to bidding the project. The ED shall provide line voltage wiring conduit and junction boxes for the express purpose of temperature controls. It shall be the responsibility of the Temperature Control Contractor to coordinate the location of the junction boxes (if not otherwise shown on the Electrical Drawings) and to utilize these junction boxes for temperature control wiring. The Temperature Control Contractor shall extend line and/or low voltage wiring from junction boxes to all mechanical and control components which require control wiring.
2. Footnote 2: Wiring from the fire alarm electrical contacts to fire alarm system control panel by ED; all mechanical equipment control function wiring by TD. ED to coordinate locations of electrical contact with MD. MD to coordinate locations of duct smoke detectors with ED.
3. Footnote 3: Device is used in the power wiring circuit to the equipment. Control functions do not exist.
4. Footnote 4: Unless furnished with equipment.
5. Footnote 5: A manually operated remote shutdown switch(es) shall be located just outside the water heater room door and marked for easy identification. Consideration should be given to the type and location of the switch to safeguard against tampering. If the water heater room door is on the building exterior, the switch should be located just inside the door. If there is more than one door to the water heater room, there should be a

switch located at each door. The emergency shutdown switch shall be wired to the water heater safety circuit relay and shall disconnect all power to the water heater safety circuit.

6. Footnote 6: TD shall provide 24V to emergency power off switches.

C. Provide Division 26 with a complete summary list of all plumbing equipment control requiring electric power within 30 days after award of contract. This list shall summarize equipment power loads, line voltage control requirements, quantities, and locations of equipment and connection points. If any plumbing equipment is required to run on emergency power, the list shall note that requirement along with the requirement for the building temperature controls systems to also be under emergency power.

1.18 DELIVERY, STORAGE AND HANDLING

A. Comply with requirements specified in Section 016000 – Product Requirements.

1.19 WARRANTIES

A. See Section 017800 – Closeout Submittals for general warranty requirements.

1.20 SCHEDULE OF TESTING

A. See Section 014533 – Code Required Special Inspections for testing requirements and procedures.

B. Make all specified tests on piping and related systems as necessary. Demonstrate the proper operation of equipment installed under this project.

C. Equipment shall not be tested, or operated for any purpose until fully lubricated in accordance with manufacturer's instructions and until connections to fully operative systems have been accomplished.

D. A schedule of testing shall be prepared in such a manner that it will show areas tested, test pressure, length of test, date, time and signature of testing personnel. All testing must be performed in the presence of the General Contractor's representative; his signature for verification of the test must appear on the schedule. At completion of testing, the schedule shall then be submitted in triplicate to the Architect.

E. Make sure operational and performance tests are made on seasonal equipment (equipment not operating year-round).

1.21 DEMONSTRATION OF ACCESS

A. The Contractor shall demonstrate to the Owner’s designated representative the access to all switches, valves, actuators, dampers, motors, lubrication lines, sensors and panels. Contractor shall correct deficiencies noted by the Owner. Refer outstanding issues to the Architect/Engineer for resolution. Contractor to be responsible for arranging the demonstration prior to final inspection.

1.22 KEYS

A. Keys: Upon completion of work, submit keys for plumbing equipment, panels, etc. to the General Contractor.

1.23 OPERATING AND MAINTENANCE DATA

A. See Section 017800 –Closeout Submittals for Operating and Maintenance Manual requirements.

1.24 INSTRUCTIONAL SESSIONS

A. See Section 017900 - Demonstration and Training for all instruction session requirements. Provide separate training on respective systems per this section.

PART 2 - PRODUCTS

2.01 MOTORS

A. Motor Characteristics: Except where more stringent requirements are indicated, comply with the following requirements for motors of mechanical work:

1. Temperature Rating: Rated for 104°F environment with maximum 122°F temperature rise for continuous duty at full load (Class A Insulation).
2. Altitude Deration: Motors to be furnished to maintain specified rated service factor at altitude of project.
3. Starting Capability: Provide each motor capable of making starts as frequently as indicated by automatic control system, and not less than 5 starts per hour for manually controlled motors.
4. Phases and Current Characteristics: Provide squirrel-cage induction polyphase motors for 3/4 hp and larger. Provide capacitor-start single-phase motors for 1/2 hp and smaller; except 1/6 hp 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. Do not purchase motors until power characteristics available at locations of motors have been confirmed, and until rotation directions have been confirmed.
5. Power Factor: All motors rated greater than 1000 watts shall have a Power Factor of not less than 85% under rated load conditions. The 85% PF may be obtained by design of the motor or by providing a capacitor. Capacitors, if provided to obtain the 85% PF, must be switched with the motor. If the motor draws less than 1000 watts at full load, it is excluded from the 85% power factor requirement.
6. Efficiency: Motor efficiency ratings shall conform to NEMA Standard MG-1-2011.
7. Service Factor: 1.15 for three-phase motors and 1.35 for single-phase motors.

B. Motor Construction: Provide general purpose, continuous duty motors, Design "B" or "C" where required for high starting torque. Provide inverter duty motors, for all variable speed motor applications:

1. Frames: NEMA No. 56.
2. Bearings: Ball or roller bearings with inner and outer shaft seals, regreasable except permanently sealed where motor is normally inaccessible for regular maintenance. Provide double shielded ball bearings in accordance with ANSI-B 3.16-1972.
3. 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.
4. 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.
5. Overload Protection: Provide built-in thermal overload protection and, where indicated, provide internal sensing device suitable for signaling and stopping motor at starter.
6. Noise Rating: Provide "Quiet" rating on motors. Motors shall not exceed 80 DB at full speed and power.

C. Name Plate: Provide metal nameplate on each motor, indicating full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

D. Manufacturer: Except where item of mechanical equipment (which otherwise complies with requirements) must be integrally equipped with motor produced by another manufacturer, provide motors for mechanical equipment manufactured by one of the following:

1. Allis-Chalmers Corp.
2. Baldor Electric Co.
3. Century Electric Div., Inc.
4. General Electric Co.
5. Louis Allis Div.; Litton Industrial Products, Inc.
6. Marathon Electric Mfg. Corp.
7. Reliance Electric Co.
8. Westinghouse Electric Corp.

2.02 STARTERS

A. Motor Starter Characteristics: Comply with NEMA standards and NEC. Provide enclosures NEMA Type as required with padlock ears, and with frames and supports for mounting on wall, floor or panel as indicated. Where starter location is not within sight of motor, provide fused disconnect switch within sight of motor. Provide type and size of starter recommended by motor manufacturer and equipment manufacturer for applicable protection and start-up condition; refer to individual equipment sections for basic load requirements.

1. Manual Switches: Provide manual switch and pilot light for motors 1/2 hp and smaller, except where interlock or automatic operation is indicated. Provide extra switch positions and pilot lights for multi-speed motors.

a. Overload Protection: Provide melting alloy type thermal overload relays.

B. Unless furnished otherwise, provide over current protection for each motor. Coordinate with Division 26.

C. Motor Starter Manufacturer: Provide motor starters for mechanical equipment manufactured by one of the following:

1. ABB.
2. Allen-Bradley Co.
3. Cutler-Hammer, Inc.
4. General Electric Co.
5. Sprecher & Schuh.
6. Square D Co.
7. Westinghouse Electric Co.

2.03 ACCESS DOORS

A. See Section 083100 – Access Doors and Panels.

B. Furnish access doors where shown on Drawings and at all locations where required for access to concealed valves, shock absorbers, dampers, cleanouts, control devices, coils, and equipment servicing. Access doors shall be 12” x 12” for hand access and 24” x 24” for head and shoulder access, or as indicated.

PART 3 - EXECUTION

3.01 INSTALLATION OF MOTORS AND STARTERS

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 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. Install starters and wiring devices securely supported and anchored, and in accordance with manufacturer's installation instructions. Locate for proper operational access, including visibility, and for safety.

C. Install control connections for motors to comply with NEC and applicable provisions of Division 26 sections.

3.02 ACCESS TO PLUMBING WORK

A. Installation:

1. Provide access doors for installation and provide instructions for their location. Exact location of access doors to be as directed by Mechanical Contractor and Architect/Engineer.
2. Furnish all access doors whether shown or not.
3. Comply with manufacturer's instructions for installation of access doors.
4. Coordinate installation with work of other trades.

5. Set frames accurately in position and securely attach to supports with face panels plumb or level in relation to adjacent finish surfaces.
6. Access door location shall be coordinated with Architect/Engineer prior to installation. All access panels not coordinated will run the risk of removal and relocation at the expense of the contractor.
7. Install access doors for the following concealed equipment:

    a. Shock absorbers.
    b. Valves.
    c. Control devices.
    d. Trap primers.
    e. Other plumbing equipment requiring service.

B. Adjust and Clean:

1. Adjust hardware and panels after installation for proper operation.
2. Remove and replace panels or frames that are warped, bowed, or otherwise damaged.

3.03 EXCAVATING FOR MECHANICAL WORK

A. Refer to Section 312300 – Earthwork.

B. 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.

C. All trenches deeper than the footing of any building or structure and paralleling the same shall be at least forty-five (45) degrees therefrom, unless permission is otherwise granted by the Administrative Authority and Structural Engineer.

D. Excavation for Trenches: Dig trenches to uniform width required for particular item to be installed, sufficiently wide to provide ample working room. Provide 6" to 9" clearance on both sides of piping:

1. Excavate trenches to depth indicated or required. Carry depth of trenches for piping to establish indicated flow lines and invert elevations. Beyond building perimeter, keep bottoms of trenches sufficiently below finish grade to avoid freeze-ups.
2. Where rock is encountered, carry excavation 6" below required elevation and backfill with 6" layer of 3/4" gravel prior to installation of pipe.
3. Where bedding is required, backfill with sand 6" below and 6" above pipe.
4. For piping 5" or less in nominal size, do not excavate beyond indicated depths. Hand excavate bottom cut to accurate elevations and support piping on undisturbed soil.
5. For piping 6" and larger in nominal size, tanks, and other mechanical work indicated to receive sub-base, excavate to sub-base depth indicated, or if not otherwise indicated, to 6" below bottom of work to be supported.
6. Grade bottoms of trenches as indicated, notching under piping couplings to provide solid bearing for entire body of piping.

E. Shape sub-bases and bottoms of excavations with recesses to receive pipe bells, flanged connections, valves and similar enlargements in piping systems.

3.04 BACKFILLING

A. Do not backfill until installed mechanical work has been tested and accepted, wherever testing is indicated.

B. All excavations shall be completely backfilled as soon after inspection as practical. Adequate precaution shall be taken to ensure proper compactness (95% density) of backfill around piping without damage to such piping. Trenches shall be backfilled in thin layers to twelve (12) inches (0.3m) above the top of the piping with clean earth which shall not contain stones, boulders, cinderfill, or other materials which would damage or break the piping or cause corrosive action. Mechanical devices such as bulldozers, graders, etc., may then be used to complete backfill to grade. Fill shall be properly compacted (95% density). Suitable precautions shall be taken to ensure permanent stability for pipe laid in filled or made ground.

3.05 CUTTING AND PATCHING

A. See Section 017000 – Execution and Closeout Requirements for Cutting & Patching Procedures.

END OF SECTION 220500

SECTION 220553 - PLUMBING IDENTIFICATION

PART 1 - GENERAL

1.01 SUMMARY

A. Types of identification devices specified in this section include the following:

1. Plastic Pipe Markers.
2. Plastic Tape.
3. Underground-Type Plastic Line Marker.
4. Valve Tags.
5. Valve Schedule Frames.
6. Engraved Plastic-Laminate Signs.
7. Plastic Tags.

1.02 SUBMITTALS

A. Provide the following submittals:

1. Pipe Marker.
2. Valve Tags.
3. Engraved Signs.
4. Equipment Tags.

1.03 REFERENCES

A. American National Standards Institute (ANSI)

1. ANSI A13.1 “Scheme for Identification of Piping Systems”.
2. ANSI Z53.1 “Safety Color Code for Marking Physical Hazards”.

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

PART 2 - PRODUCTS

2.01 IDENTIFICATION MATERIALS

A. General: Where more than single type is specified for application, selection is Installer’s option, but provide single selection for each product category.

2.02 PLASTIC PIPE MARKERS

A. Pressure-Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers, complying with ANSI A13.1.

B. Insulation: Furnish 1" thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125°F (52°C) or greater. Cut length to extend 2" beyond each end of plastic pipe marker.

C. Small Pipes: For external diameters less than 6" (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:

1. Adhesive lap joint in pipe marker overlap.
2. Laminated or bonded application of pipe marker to pipe (or insulation).
3. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4" wide; full circle at both ends of pipe marker, tape lapped 1-1/2".

D. Large Pipes: For external diameters of 6" and larger (including insulation if any), provide either full-band or strip-type pipe markers, but not narrower than 3 times letter height (and of required length), fastened by one of the following methods:

1. Laminated or bonded application of pipe marker to pipe (or insulation).
2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2" wide, full circle at both ends of pipe marker, tape lapped 3".
3. Strapped-to-pipe (or insulation) application of semi-rigid type, with manufacturer's standard stainless-steel bands.

E. Lettering: Comply with piping system nomenclature as specified, scheduled or shown, and abbreviate only as necessary for each application length.

1. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.

2.03 PLASTIC TAPE

A. General: Provide manufacturer's standard color-coded pressure- sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.

B. Width: Provide 1-1/2" wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6". Provide 2 1/2" wide tape for larger pipes.

C. Color: Comply with ANSI A13.1, except where another color selection is indicated.

2.04 UNDERGROUND-TYPE PLASTIC LINE MARKERS

A. General: Manufacturer's standard permanent, bright-colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6" 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 2-layers of plastic tape.

2.05 VALVE TAGS

A. Brass Valve Tags: Provide 19-guage polished brass valve tags with stamp-engraved piping system abbreviation in 1/4" high letters and sequenced valve number 1/2" high, and with 5/32" hole for fastener.

1. Provide 1-1/2" diameter tags.

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.

C. Access Panel Markers: Provide manufacturer's standard 1/16" thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve. Include 1/8" center hole to allow attachment.

2.06 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 SSB-grade sheet glass.

2.07 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.

B. Fasteners: Self-tapping stainless-steel screws, except contact- type permanent adhesive where screws cannot or should not penetrate the substrate.

2.08 PLASTIC TAGS

A. General: Manufacturer's standard pre-printed or partially pre-printed accident-prevention tags, of plasticized card stock with matte finish suitable for writing, approximately 3-1/4" x 5-5/8", with brass grommets and wire fasteners, and with appropriate pre-printed wording including large-size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).

PART 3 - EXECUTION

3.01 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.

3.02 PIPING SYSTEM IDENTIFICATION

A. General: Install pipe markers of one of the following types on each system indicated to receive identification, and include arrows to show normal direction of flow.

1. Plastic pipe markers, with application system as indicated under "Materials" in this section. Install on pipe insulation segment where required for hot non-insulated pipes.

B. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.

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 50' along each piping run, except reduce spacing to 25' in congested areas of piping and equipment.
7. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

3.03 UNDERGROUND PIPING IDENTIFICATION

A. General: During back-filling/top-soiling of each exterior underground piping systems, install continuous underground-type plastic line marker, located directly over buried line at 6" to 8" below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 16", install single line marker. For tile fields and similar installations, mark only edge pipe lines of field.

3.04 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, and 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.

B. Mount valve schedule frames and schedules in boiler rooms where indicated or, if not otherwise indicated, where directed by Architect/Engineer.

3.05 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, including safety devices and hazardous units such as gas outlets.
2. Meters, gauges, thermometers and similar units.
3. Fuel-burning units including water heater.
4. Pumps and similar motor-driven units.
5. Tanks and pressure vessels.
6. Strainers, filters, and similar equipment.

B. Optional Sign Types: Where lettering larger than 1" height is needed for proper identification, because of distance from normal location of required identification, stenciled signs may be provided in lieu of engraved plastic, at Installer's option.

C. Lettering Size: Minimum 1" high lettering for name of unit.

D. 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.

END OF SECTION 220553

SECTION 220700 - PLUMBING INSULATION

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Types of plumbing insulation specified in this section include the following:

1. Piping System Insulation:

a. Glass Wool / Fiberglass.

1.02 QUALITY ASSURANCE

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

B. Surface-Burning Characteristics: For insulation and related materials UL/ULC Classified per UL 723 or meeting ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

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

1.03 SUBMITTALS

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

B. Provide the following submittals:

1. Pipe Insulation.
2. Pipe fitting insulation.
3. Adhesives.
4. Sealants.
5. Mastics.

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS

A. General:

1. Products shall not contain asbestos, lead, mercury, or mercury compounds if possible. Products shall be Certified UL GREENGUARD Gold or Indoor Advantage Gold, if possible.
2. Insulation materials applied to carbon steel shall be Mass Load Corrosion Rate (MLCR) tested per ASTM 1617.
3. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
4. All insulation materials installed within a plenum shall meet a flame spread rating of 25 and a smoke developed rating of 50 when tested per ASTM E84.
5. Factory Applied Jacketing:

   a. ASJ – All Service Jacket. Kraft paper, fiberglass-reinforced scrim, with aluminum backing. Paper-white finish**.**
   b. ASJ-SSL – ASJ with Self Seal Lap. Self-sealing, pressure-sensitive, acrylic based adhesive covered by removable protective strip. No staple, faster install, for piping.

B. Piping Insulation:

1. Glass Wool / Fiberglass, Preformed Pipe Insulation:

   a. Type I, 850° F min. Materials: Glass Wool / Fiberglass bonded with a thermosetting resin. Comply with ASTM C 585, ASTM C 411, ASTM C795, and ASTM C 547, Type I and Type IV, with factory-applied ASJ.

      1) Factory Applied Jacket:

         a) ASJ-SSL – comply with ASTME C 1136, Type 1.

      2) Field Applied Jacket:

         a) See requirements below.

      3) Acceptable Manufacturers:

         a) Johns Manville: Micro-Lok HP
         b) Knauf Insulation: Earthwool 1000°
         c) Owens Corning: Fiberglass Pipe Insulation

2.02 ADHESIVES

A. General:

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

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. ASJ Adhesive:

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

2.03 MASTICS

A. General:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Vapor-Barrier Mastic:

1. Water based; suitable for indoor use on below-ambient services.
2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.04 at 40-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 52 percent by volume and 62 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic:

1. Solvent based; suitable for outdoor use on below-ambient services.
2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

2.04 SEALANTS

A. General

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. ASJ Flashing Sealants:

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

2.05 FIELD-APPLIED JACKETS

A. General:

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

PART 3 - EXECUTION

3.01 GENERAL

A. Inspection: Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

B. Insulation Thickness: Pipe insulation thickness shall be in accordance with the minimum thicknesses listed in the latest edition of the International Energy Conservation Codes and ASHRAE 90.1.

C. R Values: Insulation R values shall be in accordance with the latest edition of the International Energy Conservation Codes.

3.02 PLUMBING PIPING SYSTEM INSULATION

A. General: Insulate plumbing piping per the following table.

HVAC PIPING INSULATION SCHEDULE					
System	**Location**	**Type**	**Pipe Size**	**Thickness**	**Jacket**
40°F-60°F • Domestic Cold-Water Piping • Air Conditioner Condensate Drain Piping	Interior	Glass Wool / Fiberglass	All	1”	Factory ASJ-SSL Vapor Barrier
	Exterior or in Tunnel	Glass Wool / Fiberglass	All	2"	Factory ASJ-SSL SSL Vapor Barrier
• Roof/Overflow Drain Horizontal Piping • Roof/Overflow Drain Bodies & 1st Vertical Portion	Interior	Glass Wool / Fiberglass	All	1"	SSL Vapor Barrier with Aluminum Jacket

HVAC PIPING INSULATION SCHEDULE					
System	**Location**	**Type**	**Pipe Size**	**Thickness**	**Jacket**
105°F-140°F • Domestic Hot Water • Domestic Hot Water Recirculation Piping	Interior	Glass Wool / Fiberglass	≤ 1-1/4”	1"	Factory ASJ-SSL
			1-1/2” to 2”	1-1/2”	
			2-1/2” & up	2”	
	In Tunnel or Crawlspace	Glass Wool / Fiberglass	≤ 1-1/4”	2"	Factory ASJ-SSL with Aluminum Jacket
			1-1/2” and up	2-1/2”	

B. Insulation Omitted:

1. Omit insulation on chrome-plated exposed piping (except for ADA fixtures), air chambers, unions, strainers, check valves, balance cocks, flow regulators, drain lines from water coolers, drainage piping located in crawl spaces or tunnels, buried piping, fire protection piping, and pre-insulated equipment.
2. Provide insulation within building partition wall.
3. Encase pipe fitting insulation with flame and smoke rated one-piece premolded PVC fitting covers, fastened as per manufacturer’s recommendations.

3.03 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.

B. Install insulation on pipe systems subsequent to installation of heat tracing, painting, 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 insulation, and protect to prevent puncture or other damage.

F. Insulation Installation on Valves and Pipe Specialties: Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Apply insulation as follows:

1. Install preformed section of same material as straight segments of pipe insulation when available.

2. When pre-formed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

G. Insulation Installation on Pipe Flanges:

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

H. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation.
2. Install with preformed pipe fitting covers as scheduled.

   a. Overlap at longitudinal seams and end joints for horizontal applications.
   b. Seal with manufacturer’s adhesive. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

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

J. Insulation should go through the hanger with the insert carefully placed in a notch in the insulation at the 6 o’clock position between the pipe and the shield. For hot pipes, apply 3" 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" wide vapor barrier tape or band.

K. Install insulation and vapor barrier jackets continuous over piping at trapeze hangers.

3.04 INSTALLATION OF PLUMBING 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.

B. 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.

C. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.

D. Do not apply insulation to equipment, breechings, or stacks while hot.

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

F. 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.

G. Cover insulated surfaces with all-service jacketing neatly fitted and firmly secured. Lap seams at least 2". Apply over vapor barrier where applicable.

H. Do not insulate water heater manholes, hand holes, cleanouts, ASME stamp, and manufacturer's nameplate. Provide neatly beveled edge at interruptions of insulation.

I. 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.

J. Equipment Exposed to Weather: Protect outdoor insulation from weather by installation of aluminum weather-barrier protective jacketing.

3.05 PROTECTION AND REPLACEMENT

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

B. Replace and repair insulation disturbed by testing and balancing procedures required under Section 230593 – Testing, Adjusting and Balancing.

C. 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 221000 - PIPE, VALVES & PIPE SPECIALTIES

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Types of equipment specified in this section include the following:

1. Pipes and Pipe Fittings.
2. Valves.
3. Pipes Specialties.
4. Expansion Devices.
5. Supports and Anchors.
6. Gauges.

1.02 SUBMITTALS

A. Provide the following submittals:

1. Pipe and Fittings.
2. Soldering and Brazing Material.
3. Valves.
4. Backflow Preventers.
5. Escutcheons.
6. Strainers.
7. Dielectric Fittings.
8. Fire Barrier Sealants.
9. Water Hammer Arrestors.
10. Sleeve Seals.
11. Hangers and Supports.
12. Shields.
13. Thermometers.
14. Pressure Gauges.

1.03 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.
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.

PART 2 - PRODUCTS

2.01 PIPE AND FITTINGS

A. Shall be of material, weight, ASTM and ANSI Designation, and pressure ratings as follows unless specifically accepted otherwise.

B. Above Ground Storm Drain, Waste, and Vent Piping:

1. Pipe Size 10" and Smaller: Hubless cast-iron soil pipe fittings conforming to CISPI 301 with third party listing by NSF. Acceptable manufacturers: AB&I, Charlotte Pipe, and Tyler Pipe.

a. Hubless Joints:

1) Standard couplings equal to CISPI 310.

a) All vent piping

2) Heavy-Duty Couplings with 304 stainless steel band, bolts, etc. equal to Husky 2000, Clamp-All 80, Mission HD, Ideal HD on the following piping:

a) All waste piping

3) Extra Heavy-Duty Coupling with all stainless-steel band, bolts, etc. equal to Husky SP4000.

a) All roof drain, overflow drain and storm drain piping.
b) Drainage piping above **operating rooms, nursery and computer related rooms**.

2. Pipe size 1 1/2" and Smaller: DWV copper with DWV pattern solder joints.

C. Underground Storm Drain and Building Drain Piping to 5 Feet Beyond Building Line:

1. Pipe size 8" and smaller: Schedule 40 PVC solid core (only), PVC-DWV pipe with DWV drainage fitting and solvent welded joints. ASTM D-2665, ASTM D-2321 (underground installation) and ASME B31.3 (Bunder's Qualification).

D. Domestic Water Service Outside of Building:

1. 3" and Smaller: Type "K" hard drawn copper, all joints to be brazed.

E. Domestic Hot and Cold Water Underground Inside Building: Include 10'-0" plus or minus outside of building wall.

1. 2-1/2" and Under:

a. Pipe: Copper water tube, heavy wall thickness, annealed temper; ASTM B 88, Type K.
b. No fittings or joints allowed underground, below floor slabs.

2. 2” and Smaller:

   a. Pipe: PEX piping equal to Uponor “AquaPEX” (PEX-A), high density polyethylene, cross linked. Must meet the following standards: ASTM F876, ASTM F877, ASTM F1807, ASTM, 1960, ASTM F2080, ANSI/NSF Standard 14 and 61.
   b. Fittings: C314 red brass or polyethylene fittings only.

F. Domestic Cold Water, Hot Water, Hot Water Recirculation and Condensate Piping Above Ground Inside Building:

1. 4” and Under:

   a. Pipe: Type L, hard drawn, seamless copper tubing ASTM B 88-70.
   b. Fittings: Wrought copper solder joint pressure type fittings as per ANSI B16.22 or cast copper solder joint fittings as per ANSI B16.18.
   c. Joints: Canfield 100% watersafe solder for pipe sizes 1 ½” and smaller, and brazed joints 2” and larger. Antimony is not allowed in solder.

2. 4” and Under

   a. Press Fittings: Copper press fittings shall conform to the material and sizing requirements of ASME B16.18 or ASME B16.22. O-rings for copper press fittings shall be EPDM.
   b. Manufacturers for copper press fittings:

      1) Viega, 17545 Daleview Dr., Lakewood, OK 44107, 877-620-0016
      2) Nibco, Inc.
      3) Apollo X-Press (Elkhart).
      4) Or Approved Equal.

G. Natural Gas and Natural Gas Relief Vent Piping, Above Ground Inside Building and Above Ground Exterior:

1. Pipe: Schedule 80 ASTM A-53, Grade B, Type E for pipe sizes 1/2" and under; Schedule 40 ASTM A-53, Grade B, Type E for pipe sizes over 1/2".
2. Fittings:

   a. ½” and Under: 300-pound malleable iron (ASTM B16.2) flat banded pattern screwed fittings per ANSI B16.3.
   b. Over ½” thru 2": Same as above except 150-pound class, screwed or welding fittings per joints below.
   c. Over 2": Schedule 40, seamless carbon steel welding fittings, long radius, 150-pound class, dimensions per ANSI B16.9-1971; ASTM A 234-73, Grade WPB.

3. Joints:

   a. 2” and Under: Threaded using joint compound resistant to gas-air mixture.
   b. 2-1/2" and Above: Butt-welded.
   c. Note: Weldolets, Threadolets, Sockolets, where permitted by authorities having jurisdiction may be used in lieu of standard fittings on natural gas piping.

H. Natural Gas, Below Ground Outside Building:

1. Pipe: Black steel Schedule 40, seamless steel pipe per ASTM A 53.

   a. Fittings: Schedule 40, seamless carbon steel welding fittings, 150 LB. Class.
   b. Joints: Butt-welded.
   c. Wrapping: Machine wrap, 50% overlap wrap with polyvinyl chloride tape. Hand wrap fittings using 100% overlap wrap extending 6" beyond fitting onto wrapped pipe.

2. Pipe: High density polyethylene (PE piping) gas piping ASTM D2513. SDR 11.
3. PE Fittings: ASTM D 2683m socket fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
4. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
5. Anodeless Service-Line Risers: Factory fabricated and leak tested.

   a. Underground Portion: PE piping complying with ASTM D 2513, SDR 11 inlet.
   b. Above ground Portion: PE transition fitting.
   c. Outlet shall be threaded or flanged or unsuitable for welded connection.
   d. Tracer wire connection.
   e. Ultraviolet shield.
   f. Stake supports with factory finish to match steel pipe casing or carrier pipe.

6. PE Fittings: ASTM D 2683, socket fusion type or ASTM D 3261

2.02 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 AWS D10.12M/D1.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
2. 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. Canfield 100% Water Safe. "No Antimony."

C. Brazing Materials: Except as otherwise indicated, provide brazing materials as determined by Installer to comply with installation requirements.

1. AWS A5.8/5.8M BCuP Series, copper-phosphorus alloys for joining copper with copper.
2. 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 for cast- iron flanges; raised-face for steel flanges, unless otherwise indicated.

E. Solvent Cements for Plastic Piping:

1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

a. PVC solvent cement shall have a VOC content of 510g/L or less.
b. Adhesive primer shall have a VOC content of 550 g/L or less.
c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of the Public Health's (formerly California Health Services) "Standard method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

F. 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.

1. Acceptable Manufacturers:

a. Fernco, Inc.
b. Indiana Seal
c. Anaco.

2.03 VALVES

A. General: 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. Valves shall be manufactured in accordance with all applicable M.S.S. Standards. All ball and globe valves intended to supply drinking water shall meet NSF-61 (180° F C. Hot). All valves installed in the plumbing system shall be lead free.

B. Sizes: Unless otherwise indicated, provide valves of same size as upstream pipe size.

C. Operators: Provide handwheels, fastened to valve stem, for valves other than quarter-turn. Provide lever handle for quarter-turn valves, 6" and smaller, other than plug valves. Provide one wrench for every 10 plug valves.

D. Acceptable Manufacturer's

1. Gate Valves (Fire Protection Only)

a. Victaulic.
b. Kennedy.
c. Gruvlok.

2. Globe Valves and Swing Check Valves:

a. Apollo.

b. Hammond/Milwaukee Valve Corp.
c. Nibco, Inc.
d. Watts.

3. Drain Valves:

a. Apollo.
b. Hammond/Milwaukee Valve Corp.
c. Nibco, Inc.
d. Viega (Press Fit only)

4. Gas Plug Valves:

a. DeZurik Co.
b. Walworth Co.

5. Gas Cocks:

a. Conbraco/Apollo.
b. DeZurik Corp.
c. Nibco, Inc.

6. Ball Valves:

a. Apollo.
b. Hammond/Milwaukee Valve Corp.
c. Nibco, Inc.
d. Watts Co.
e. Viega (Press Fit only)

7. Balance Valve (2" and smaller Venturi Type):

a. Armstrong.
b. Flowset-Flow Design Inc.
c. Gerand.
d. Preso.
e. Griswold

8. Balance Valve (2" and smaller variable CV orifice type):

a. Armstrong.
b. Bell & Gossett.
c. Nibco, Inc.
d. Tour – Anderson.

9. Reduced Pressure Backflow Preventer and Detector Assembly:

a. Apollo.
b. Febco Sales, Inc.
c. Watts.
d. Zurn/Wilkins.

10. Double Check Backflow Preventer and Detector Assembly:

    a. Ames.
    b. Apollo.
    c. Febco Sales, Inc.
    d. Watts.
    e. Zurn/Wilkins.

E. Valve Features:

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. All valves in the plumbing system shall be lead free.
2. Flanged: Valve flanges complying with ANSI B16.1 (cast iron), ANSI B16.5, (steel), or ANSI B16.24 (bronze).
3. Threaded: Valve ends complying with ANSI B2.1.
4. Butt-Welding: Valve ends complying with ANSI B16.25.
5. Solder-Joint: Valve ends complying with ANSI B16.18.
6. Flangeless: Valve bodies manufactured to fit between flanges complying with ANSI B16.1 (cast iron), ANSI B16.5 (steel), or ANSI B16.24 (bronze).

Delete below if Press fittings are now allowed.

7. Press Ends: Valve end comply with ANSI B 75 or ANSI B 88.

F. Valve Schedule:

1. General: Provide the following valves for various valve types referenced in Division 22 sections.
2. Gate Valves (Fire Protection Only):

    a. Threaded End; 2" and Smaller: FM, UL-listed, 175 psi, bronze body solid wedge, outside screw and yoke, rising stem.

        1) Nibco, Inc. T-104-0.

    b. Flanged End; 2-1/2" and Larger: FM, UL-listed, 175 psi, iron body bronze mounted, solid wedge, outside screw and yoke, rising stem.

        1) Nibco, Inc. F-607-0.

3. Globe Valves:

    a. 2” and Smaller: 125 lb. SWP, bronze body, screw-in bonnet, integral seat, renewable disc. Conform to MSS SP-80 (NSF 61 - 180° F C. Hot). Lead free.

        1) Threaded Ends

            a) Apollo 121TLF.
            b) Hammond/Milwaukee UP502.

2) Solder Ends:

a) Apollo 120TLF.
b) Hammond/Milwaukee UP1502.

4. Drain Valves:

a. 125 lb. SWP: Bronze body, screw-in bonnet, rising stem, composition disc, 3/4" hose outlet, provide cap and chain. Conform to ASSE 1005. Lead free.

1) Threaded End:

a) Apollo 70LF-10X-HC
b) Nibco, Inc. S-585-80-LF-HC.

2) Solder Ends:

a) Apollo 70LF-20X-HC

5. Ball Valves:

a. See sizes below. 600 CWP/150 SWP, bronze body, full port, bronze trim, 2-piece construction, TFE seats and seals (NSF 61 - 180° F C. Hot). Lead free.

1) Solder

a) ½” to 2 ½”: Apollo 77CLF-200.
b) ½” to 2”: Milwaukee UPBA-450
c) ½” to 2”: Nibco, Inc. S-585-80-LF.

2) Threaded

a) ½” to 2 ½”: Apollo 77CLF-100.
b) ½” to 2”: Milwaukee UPBA-400.
c) ½” to 2”: Nibco, Inc. T-585-80-LF.

6. Swing Check Valves:

a. 3” and Smaller: 125 lb. SWP, bronze body, horizontal swing, straight pattern flow renewable disc, lead free. Conform to MSS SP-80.

1) Threaded Ends:

a) Apollo 161TLF.
b) Nibco, Inc. T-433-Y-LF.

2) Solder Ends:

a) Apollo 161SLF
b) Nibco, Inc. S-433-Y-LF.

b. 2-1/2” and Larger FM (Fire Protection Only): 175 psi, iron body, teflon disc, bronze mounted, renewable composition disc and bronze seat ring, bolted cover, flanged ends.

1) Crane/ Stockham G-940.
2) Nibco, Inc. F-918B.

7. Gas Plug Valve:

a. 2” and Smaller: 150 psi, cast-iron body, straightaway pattern, square bronze head, threaded ends.

1) DeZurik #PEC.
2) Homestead: 611.

8. Gas Cocks:

a. Gas Cocks 3" and Smaller: 250 psi non-shock CWP, bronze ball valve with chrome plated ball, threaded ends, UL listed.

1) Nibco, Inc. T-580-70-UL-842.
2) Apollo 80-100

9. Balance Valves:

a. 2” Size and Smaller: Provide balance valves equipped with readout valves to facilitate connecting of differential pressure meter to balance valves. Equip each readout valve with integral EPT check valve designed to minimize system fluid loss during monitoring process. Provide calibrated nameplate to indicated degree of closure of precision machined orifice. Construct balancing valve with internal EPT o-ring seals to prevent leakage around rotating element. Provide balance valves with preformed polyurethane insulation suitable for use on heating and cooling systems, and to protect balance valves during shipment. Must be lead free.

1) Acceptable Manufacturers:

a) Armstrong.
b) Bell & Gossett, ITT; Fluid Handling Div.
c) Tour-Anderson.
d) Nibco, Inc.

b. 2” and Smaller: One piece, non-ferrous, bronze/brass flow measuring and balancing/shut-off valve combination. The flow element shall be a low loss/high signal Venturi type (± 2% accuracy) of one to ten rangeability, equipped with dual Schrader Type pressure test posts and caps. Balancing/shutoff valves shall be ball type with large diameter plated ball, teflon seats, blow out proof stem with teflon packing and packing nut. Full size handle, grip and memory stop. Entire assembly rated to 400 WOG and tested to 100% after assembly. Must be lead free.

1) Acceptable Manufacturers:

a) Armstrong
b) Flow Design-Flowset.
c) Gerand Co.
d) Griswold (manually adjusted valves only).
e) Preso.

10. Reduced Pressure Backflow Preventer with Detector Assembly:

    a. Provide reduced pressure principle backflow preventers consisting of assembly including shutoff valves on inlet and outlet, and strainer on inlet and detector assembly. Backflow preventers shall include test cocks, and pressure-differential relief valve located between 2 positive seating check valves. Provide funnel drain assembly and airgap drain to floor drain. Construct in accordance with ASSE Standard 1013, and is USC approved and lead free.

        1) FEBCO Co. LF880V (all sizes), LF860 (all sizes).

11. Double Check Backflow Preventer with Detector Assembly:

    a. Provide double check assembly incorporating two spring loaded check valve assemblies, inlet and outlet shutoff valves and detector assembly. Construct in accordance with USC, ASSE 1015, AWWA C-510, and CSA B645. Shall be U.L. and FM approved. Provide lead free if used in domestic water system.

        1) FEBCO Co. #856ST.

2.04 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 as determined by Installer 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.

B. Pipe Escutcheons:

1. 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.
2. 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.
3. Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.
4. Acceptable Manufacturers:

    a. Brasscraft.
    b. Dearborn.

c. McGuire.
d. Zurn.

C. Strainers:

1. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125 psi working pressure, with Type 304 stainless steel screens, with 3/64" perforations @ 233 per sq. in. as a minimum.

a. Flanged Ends, 6" and Smaller in Copper Piping Systems: wye patterned cast copper silicon strainer, screwed screen retainer with centered blowdown fitted and blowdown piped to nearest drain with valve.
b. Acceptable Manufacturers:

1) Watts LF7777: 1/4” thru 4”.
2) Apollo 59LF Series: 1/8” thru 4”.

D. Dielectric Fittings:

1. General: Provide standard products recommended by manufacturer for use in service indicated, which effectively isolate ferrous from non-ferrous piping (electrical conductance), prevent galvanic action, and stop corrosion.

a. Dielectric unions and flanges shall conform to ANSI and have no flow restriction when assembled. Flanges shall be rated at 175 psi and unions at 250 psi.

1) Acceptable Manufacturers:

a) Capital MFG.
b) Epco Sales, Inc.
c) Mueller Company.
d) Watts Regulator.

b. Clearflow dielectric waterway nipple, steel nipple with inert thermoplastic liner. Shall meet ASTM F-492-77.

1) Acceptable Manufacturers:

a) Gruvlok.
b) Perfection Corporation – Victaulic.

E. Fire Barrier Penetration Seals:

1. Provide seals for any opening through fire-rated walls, floors, or ceilings used as passage for mechanical components such as piping or ductwork.

a. Cracks, Voids, or Holes Up to 4" Diameter: Use putty or caulking, one-piece intumescent elastomer, non-corrosive to metal, compatible with synthetic cable jackets, and capable of expanding 10 times when exposed to flame or heat, UL-listed.

b. Openings 4" or Greater: Use sealing system capable of passing 3-hour fire test in accordance with ASTM E-814, consisting of wall wrap or liner, partitions, and end caps capable of expanding when exposed to temperatures of 250 to 350°F (121 to 177°C), UL-listed.

c. Acceptable Manufacturers:

1) Electro Products Div./3M. (Fire Barrier Systems)
2) Mansville Products Corp.
3) Nelson; Unit of General Signal. (Flameseal)
4) Pipe Shield Incorporated.
5) STI.
6) Hilti – FS/One.

F. Water Hammer Arresters:

1. General: Provide bellows or piston type water hammer arresters, pressure rated for 250 psi, tested and certified in accordance with ASSE #1010 and lead free. Provide access panel for servicing.
2. Acceptable Manufacturers:

a. Josam Co.
b. PPP, Inc.
c. Sioux Chief.
d. Smith (Jay R.) Mfg. Co.
e. Tyler-Wade.
f. Watts.
g. Zurn Industries, Inc.; Hydromechanics Div.

2.05 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". Reinforce top, either by structural angles or by rolling top over 1/4" steel rod. Provide hole, gasket, and flange at low point for watertight joint and 1" 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 snap lock joint, welded spiral seams, or welded longitudinal joint. Fabricate from the following gauges: 3" and smaller, 20 gauge; 4" to 6" 16 gauge; over 6", 14 gauge.
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.

C. Sleeve Seals: Provide sleeve seals in sleeve as follows:

1. Below grade in foundation wall or exterior walls above grade.

a. Link seal.
b. Innerlynx

2. Penetration below grade thru floor.

    a. Provide elastomeric joint sealant to maintain watertight and airtight continuous seal.

3. Penetrations thru walls, floors, or ceilings above grade.

    a. Intumescent fire stop.

2.06 HANGERS AND SUPPORTS

A. References:

1. ASTM B633 – Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
2. ASTM A123 – Specification for Zinc (Hot Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip.
3. ASTM A653 G90 – Specification for Steel Sheet, Zinc Coated by the Hot-Dip Process.
4. MSS SP58 – Manufacturers Standardization Society: Pipe Hangers and Supports – Materials, Design and Manufacture.
5. MSS SP69 – Manufacturers Standardization Society: Pipe Hangers and Supports – Selection and Application.
6. NFPA 13 – Standard for the Installation of Sprinkler Systems.

B. Quality Assurance:

1. Hangers and supports used in fire protection piping systems shall be listed and labeled by Underwriters Laboratories.
2. Steel pipe hangers and supports shall have the manufacturer’s name, part number, and applicable size stamped in the part itself for identification.
3. Hangers and supports shall be designed and manufactured in conformance with MSS SP58.
4. Supports for sprinkler piping shall be in conformance with NFPA 13.

C. Horizontal-Piping Hangers and Supports:

1. General: Except as otherwise indicated, provide factory- fabricated horizontal-piping hangers and supports selected by Installer to suit horizontal-piping systems. 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 shield for insulated piping. Provide baked on epoxy paint hangers and supports for copper piping systems.

D. Vertical-Piping Clamps:

1. 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 baked on epoxy paint clamps for copper-piping systems.

E. Hanger-Rod Attachments:

1. 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.

F. Building Attachments:

1. 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.

G. Finishes:

1. Indoor Finishes:

a. Hangers and clamps for support of bare copper piping shall be coated with copper colored epoxy paint. Additional PVC coating of the epoxy painted hanger shall be used where necessary.
b. Hangers for other than bare copper pipe shall be zinc plated in accordance with ASTM B633 or shall have an electrodeposited epoxy finish.
c. Strut channels shall be pre-galvanized in accordance with ASTM A653 G90 or have an electrodeposited epoxy finish.

2. Outdoor Area Finishes:

a. Hangers and struts located in outdoor shall be electro-deposit epoxy finish with stainless steel hardware.

H. Acceptable Manufacturers of Hangers and Supports:

1. B-Line Systems Inc.
2. Superstrut.
3. PHD, Inc.
4. Erico.

I. Pipe Positioning Systems:

1. Description: IAPMO PS42, system of metal brackets, clips and straps for positioning piping in pipe spaces for plumbing fixtures.
2. Acceptable Manufacturers:

a. Holdrite Corp.; Hubbard Enterprises.

J. Cast Iron Piping Restraints

1. Engineered restraints for cast iron piping up to 50 feet of head pressure.

2. Acceptable Manufacturers:

a. Holdrite Corp.; Hubbard Enterprises.

K. Shields:

1. General: Except as otherwise indicated, provide shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size shields for exact fit to mate with pipe insulation.
2. Protection Shields: MSS Type 40; of length per schedule below to prevent crushing of insulation. Provide coated projection shields on cold/ chilled water piping.

a. Schedule:

Nominal Pipe or Tubing Size	Shield Length	Shield Gauge Thickness	Material
½” thru 3”	12”	18	Galvanized
4”	12”	16	Galvanized

3. Thermal Hanger Shields: MSS Type 40 Constructed of an insert of high density, 100 psi, water-proofed calcium silicate, encased in a sheet metal shield. Provide assembly of same thickness as adjoining insulation. The style of thermal hanger shield assembly shall be determined by shield manufacturer based on hanger type.
4. Acceptable Manufacturers:

a. Pipe Shields, Inc.
b. Value Engineering Products, Inc.

2.07 MISCELLANEOUS MATERIALS

A. Metal Framing:

1. Supplementary Structural Supports: Design and fabricate supports using structural quality steel bolted framing materials as manufactured by B-Line Systems. Channels shall be roll formed, 12 gauge ASTM A570 Grade 33 steel, 1 5/8” x 1 5/8” or greater as required by loading conditions. Submit designs for pipe tunnels, pipe galleries, etc., to Engineer for approval. Use clamps and fittings designed for use with the strut system.

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). Mix at a ratio of 1.0-part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.

D. Trapeze Hangers:

1. Trapeze hangers shall be constructed from 12-gauge roll formed ASTM A570 Gr. 33 structural steel channel, 1 5/8” x 1 5/8” minimum. B-Line B22 strut or stronger as required.

2. Mount pipes to trapeze with 2-piece pipe straps sized for outside diameter of pipe, B-Line B2000 Series.
3. For pipes subjected to axial movement:

    a. Strut mounted roller support, B-Line B3126. Use pipe protection shields on insulated lines.
    b. Strut mounted pipe guide, B-Line B2417.

E. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.

F. Pipe 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.

2.08 GLASS THERMOMETERS

A. General: Provide glass thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.

B. Case: Die cast aluminum finished in baked epoxy enamel, glass front, spring secured, 9" long.

C. Adjustable Joint: Die cast aluminum, finished to match case, 180°F adjustment in vertical plane, 360 degrees adjustment in horizontal plane, with locking device.

D. Tube and Capillary: Organic filled "red" color, magnifying lens, 1% scale range accuracy, shock mounted.

E. Scale: Satin faced, non-reflective aluminum, permanently etched markings.

F. Stem: Copper-plated steel, or brass, for separable socket, length to suit installation and lead free.

G. Range: Conform to the following:

    1. Hot Water: 30° - 240°F with 2°F scale divisions.

H. Acceptable Manufacturers:

    1. Ernst Gauge Co.
    2. Marshalltown Instruments, Inc.
    3. Taylor.
    4. Trerice (H.O.) Co.
    5. Weiss Instruments, Inc.
    6. Winters Thermogauge.

2.09 THERMOMETER WELLS

A. General: Provide thermometer wells constructed of brass or stainless steel, lead free, pressure rated to match piping system design pressure. Provide 2" extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.

B. Manufacturer: Same as thermometers.

2.10 PRESSURE AND TEMPERATURE GAUGE CONNECTOR PLUGS

A. General: Provide temperature and pressure gauge connector plugs pressure rated for 500 psi and 275°F. Construct of brass and finish in nickel-plate, lead free, equip with 1/2" NPT fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8" O.D. probe assembly from dial type insertion thermometer or pressure gauge. Equip orifice with gasketed screw cap and retaining strap. Provide extension, length equal to insulation thickness, for insulated piping.

B. Acceptable Manufacturers:

1. Peterson Equipment Co.

2.11 PRESSURE GAUGES

A. General: Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.

B. Type: General use, 1% accuracy, ANSI B40.1 grade A, phosphor bronze bourdon type, bottom connection.

C. Case: Drawn steel or brass, glass lens, 4 1/2" diameter.

D. Connector: Brass with 1/4" male NPT, lead free.

E. Scale: White coated aluminum, with permanently etched markings.

F. Range: Conform to the following:

1. Water: 0 - 100 psi.

G. Acceptable Manufacturers:

1. Ametek/U.S. Gauge.
2. Marsh Instrument Co.; Unit of General Signal.
3. Marshalltown Instruments, Inc.
4. Trerice (H.O.) Co.
5. Weiss Instruments, Inc.
6. Winters Thermogauge.

2.12 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" female NPT on each end, and "T" handle brass plug.

B. Snubber: 1/4" brass bushing with corrosion resistant porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served, lead free and pressure rating.

C. Manufacturer: Same as for pressure gauges.

PART 3 - EXECUTION

3.01 PIPE AND PIPE FITTING 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" misalignment tolerance.

B. Locate piping runs, except as otherwise indicated, vertically and horizontally (pitched to drain) and avoid diagonal runs wherever possible. 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" where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any. Where possible, locate insulated piping for 1" 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. 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.

D. Painting of Pipe: Paint all exterior steel piping (gas, etc.) with a rust inhibitor paint. Coordinate color with architect prior to painting.

3.02 PIPING SYSTEM JOINTS

A. General: Provide joints of type indicated in each piping system.

B. 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.

C. Braze copper tube-and-fitting joints where indicated, in accordance with ASME B31.

D. 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. Use only flux with no lead content. 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.

E. Press Connections: Copper press fittings shall be made in accordance with the manufacturer's installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool approved by the manufacturer.

F. 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-degree 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" long welds; 4 welds for pipe sizes to 10", 8 welds for pipe sizes 12" to 20".
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; re-fabricate 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. Clean all welded joints and apply prime coat rust inhibitor.

G. Weld pipe joints of steel water pipe in accordance with AWWA C206.

H. Grooved joint piping systems shall be installed in accordance with the manufacturer's (Victaulic) guidelines and recommendations. All grooved couplings, fittings, valves and specialties shall be supplied by a single manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be supplied by the grooved coupling manufacturer. Grooved end shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove. A Victaulic factory trained field representative shall provide on-site training to contractor's field personnel in the installation of grooved piping products. Factory trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

I. 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.

J. Hubless Hub & Spigot, Cast-Iron Joints: Comply with coupling manufacturer's installation instructions.

K. Plastic Pipe/Tube Joints: Comply with manufacturer's instructions and recommendations, and with applicable industry standards. Install per ASTM D-2321 (underground installation) with contractor Bunder’s Qualification per ASME B31.3.

3.03 INSTALLATION OF VALVES

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 all branch lines to isolate sections of piping whether shown or not. Branch lines will be considered any line connecting to the main piping. 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. Shutoff Valves: Install on inlet and outlet of each mechanical equipment item, and elsewhere as indicated.

C. Drain Valves: Install on each mechanical 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 hydronic piping system.

D. Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

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

F. Non-Metallic Disc: Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign material in piping system can be expected to prevent tight shutoff of metal seated valves.

G. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

H. Installation of Check Valves (5x diameter of pipe lay length away from pumps):

1. Swing Check Valves: Install in horizontal position with hinge pin horizontally perpendicular to center line of pipe. Install for proper direction of flow.

3.04 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 pipe connection. Provide drain line from shutoff valve to plumbing drain and airgap, full size of blow down connection.

1. Locate Y-type strainers in supply line ahead of the following equipment, and elsewhere as indicated, if integral strainer is not included in equipment:

a. Pumps.
b. Pressure reducing valves.
c. Main domestic water entry prior to backflow.

C. Dielectric Fittings:

1. Contractor shall use dielectric nipples wherever possible.
2. Provide dielectric pipe fittings and isolators at all connections between dissimilar metals in the domestic water and fire protection systems to control corrosion potential caused by galvanic or electrolytic action.
3. Typical locations for dielectric isolation are: water heaters, storage and pressure tanks, water conditioning equipment, pumps, changes in service piping materials, make-up connections to boilers water systems, valves, flexible connectors and the like where materials of different electrode potential are joined.
4. Storage tanks shall be isolated from piping and tank stands by use of anti-electrolytic and galvanic isolators.

D. Fire Barrier Penetration Seals: Fill entire opening with sealing compound. Adhere to manufacturer's installation instructions.

E. Water Hammer Arresters: Install in upright position, in locations of all quick closing valves and as required by code, and of sizes in accordance with ASSE #1010, and elsewhere as indicated.

3.05 INSTALLATION OF FABRICATED PIPING SPECIALTIES

A. Drip Pans: Locate drip pans under piping passing over or within 3' 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" drain line to drain connection, and run to nearest plumbing drain or elsewhere 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 Architect/Engineer. 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 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. Extend floor sleeves 1/4" above level floor finish, and 3/4" 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 penetrations; both above and below grade.
3. Install steel-pipe sleeves except as otherwise indicated.

C. Sleeve Seals: Install in accordance with the manufacturer's requirements.

3.06 EXPANSION LOOP INSTALLATION

A. General: Fabricate expansion loops as indicated, in locations indicated, and elsewhere as determined by Installer 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 indicated, and elsewhere as determined by Installer to properly anchor piping in relationship to expansion loops.

3.07 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 per local code. 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. Installation of Building Attachments:

1. Install building attachments at required locations within concrete or on structural steel for proper piping support. Space attachments within maximum piping span length indicated in MSS SP-69 Table 3 or local code, whichever is more stringent. Install additional hangers at 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 is indicated, install reinforcing bars through openings at top of inserts.

C. 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.

D. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods, or by plastic coated hangers.

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.
2. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.
3. 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.

F. 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. Shield Installation:

a. 3” and smaller piping: Contractor option: protection shields or thermal hanger shields. Provide on cold/chilled water a vapor barrier.
b. 4” and Larger: Contractors option: thermal hanger shields. Provide on cold/chilled water piping a vapor barrier.

G. Support of pipe, tubing and equipment shall be accomplished by means of engineered products, specific to each application. Makeshift, field devised methods shall not be allowed.

H. Hangers, struts and hardware in outdoor or high humidity areas including but not limited to; Natatoriums, pool locker rooms, pool chemical rooms and pool equipment rooms, shall be field painted by the general contractor. Coordinate hanger material with painting contractor prior to painting. The installing paint contractor shall provide preparation and painting suitable for the material used.

3.08 INSTALLATION OF ANCHORS AND/OR RESTRAINTS

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 principal 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.

E. Provide Restraints on cast-iron that is greater than 4” in size or as required by Codes.

1. Engineered Restraints per Section 221000 only.

3.09 EQUIPMENT SUPPORTS

A. 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.

3.10 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 in the following locations, and elsewhere as indicated:

1. At outlet of each domestic hot water storage tank and temperature mixing valve.
2. Downstream of hot water recirculation pump.

C. Thermometer Wells: Install in piping tee where indicated, in vertical upright position. Fill well with oil or graphite, secure cap.

D. Temperature Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.

3.11 INSTALLATION OF PRESSURE AND TEMPERATURE TEST PLUGS

A. General: Install in piping where indicated, located on pipe at the most readable position. Secure cap.

B. For horizontal pipe, install in top half of pipe line.

3.12 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 discharge of each pressure reducing valve.
3. At water service and fire service entry. Prior to backflow preventer.

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.

3.13 CLEANING, FLUSHING, INSPECTING

A. General: Clean exterior surfaces of superfluous materials, and prepare for application of specified coatings (if any). Flush out 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. Disinfection of Domestic Water Piping System

1. Disinfect water mains and water service including all new and existing inside building domestic HW, CW and HWC piping.
2. Disinfection of piping and testing shall be completed a minimum of one week prior to occupancy.
3. Prior to starting work, verify system is complete, flushed and clean.
4. Ensure Ph of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
5. Inject disinfectant free chloride in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/K residual.
6. Bleed water from outlets to ensure distribution and test for disinfectant residual at a minimum 15 percent of outlets.
7. Maintain disinfectant in system for 24 hours.
8. If final disinfectant residual tests less than 25 mg/L, repeat treatment.
9. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
10. Take samples no sooner than 24 hours after flushing, from 5 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

C. Disinfect water mains and water service including all new and existing inside building domestic HW, CW and HWC piping in accordance with the authority having jurisdiction or, if methods are not prescribed, in accordance with AWWA C651. Disinfection of piping and testing shall be completed a minimum of one week prior to occupancy.

3.14 PIPING TESTS

A. Test pressure piping in accordance with ASME B31.

B. General: Provide temporary equipment for testing, including pump and gauges. 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. Air may be used if allowed by Code. Air cannot be used for plastic piping.

1. Required test period is 8 hours.
2. Test each piping system at 150% of operating pressure indicated, but not less than 100 psi test pressure.
3. Test drainage piping systems at a nominal pressure of 10 ft. hydrostatic head.
4. Observe each test section for leakage at end of test period. Test fails if leakage is observed or if pressure drop exceeds 5% of test pressure.

C. 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.

D. Drain test water from piping systems after testing and repair work has been completed.

END OF SECTION 221000

SECTION 222000 - PLUMBING SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Refer to Section 221000 – Pipes, Valves and Piping Specialties.

1.02 DESCRIPTION OF WORK

A. Systems and equipment specified in this section include the following:

1. Potable Water System.
2. Storm Water, Waste and Vent System.
3. Natural Gas System.
4. Plumbing Fixtures.
5. Plumbing Pumps.
6. Water Heaters.
7. Compressed Air Systems.

1.03 SUBMITTALS

A. Provide the following submittals:

1. Potable Water Specialties.
2. Thermostatic Mixing Valves.
3. Expansion Tank.
4. Gas Regulators.
5. Cleanouts.
6. Drains.
7. Gas Control Panels & Solenoid Valves.
8. Plumbing Fixtures & Trim.
9. Pumps.
10. Water Heaters.
11. Compressed air specialties.

PART 2 - PRODUCTS

2.01 MATERIALS AND PRODUCTS

A. General: Provide piping materials and factory-fabricated piping products, and specified equipment of sizes, types, pressure ratings, temperature ratings, and capacities as indicated. Provide sizes and types matching piping and equipment connections and provide fittings of materials which match pipe materials. Where more than one type of materials or products are indicated, selection is Installer's option.

2.02 PIPES, PIPE FITTINGS AND ACCESSORIES

A. Basic Valves: Refer to Section 221000 for valve and manufacturer Specification.

1. Sectional and Shutoff Valves:

   a. 2" and Smaller: Ball valves.

2. Drain Valves:

   a. 2" and Smaller: Ball valves.

3. Check Valves:

   a. All Sizes: Swing or lift check valves.

4. Balancing Valves:

   a. All sizes: Calibrated or Venturi type only; positive shut-off.

2.03 POTABLE WATER SPECIALTIES

A. Hose Bibbs

1. HB-1: Chicago Faucet Co. No. 952; Threaded end, chrome plated, bronze body, renewable composition disc, tee handle, 3/4" NPT inlet, 3/4" hose outlet, integral vacuum breaker.
2. HB-2: Zurn Z-843M1SCRC, service faucet (HW & CW), wall mounted with pail hook, vacuum breaker. Connect ¾” hose to hose reel.
3. Acceptable Manufacturers:

   a. Chicago Faucet Co.
   b. Mifab, Inc.
   c. Prier Co.
   d. Smith, (Jay R.) Mfg. Co.
   e. T & S Brass and Bronze Co.
   f. Zurn.

B. Wall Hydrants

1. WH-1: Woodford Model B67; non-freeze cast-bronze/brass box hydrant, polished bronze/brass plated face, tee handle key, bronze casing, length to suit wall thickness, integral vacuum breaker, self-draining, hinged locking cover, 3/4" inlet, hose outlet.
2. Acceptable Manufacturers:

   a. Josam Mfg. Co.
   b. Mifab, Inc.
   c. Smith, (Jay R.) Mfg. Co.
   d. Woodford Mfg. Co.
   e. Watts Co.
   f. Zurn Industries Inc., Hydromechanics Div.

C. Roof Hydrants

1. RH-1: Woodford #SRH-MS, non-freeze, automatic draining reservoir, built-in vacuum breaker, cast-iron deck support and flange, secured in roof deck, roof flashing.
2. Acceptable Manufacturers:

    a. Woodford Mfg. Co.
    b. MAPA Products (Roof hydrants only).

D. Connection Outlet

1. Ice Maker Box (IMB-1): Sioux Chief #696-101, white ABS, Type L copper, “AA” water hammer arrestor, face plate.
2. Washer Box (WB-1): Sioux Chief #696-2313, white ABS, Type L copper, “AA” water hammer arrestor face plate.
3. Acceptable Manufacturers:

    a. Sioux Chief.
    b. IPS Corporation.
    c. Oatey.
    d. Proset Systems.

E. Backflow Preventers

1. Refer to Section 221000 for Specification.

F. Relief Valves

1. Provide 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.
2. Acceptable Manufacturers:

    a. Cash (A. W.) Valve Mfg. Corp.
    b. Conbraco Industries, Inc.
    c. Watts Regulator Co.
    d. Zurn Industries, Inc.; Wilkins-Regulator Div.

G. Water Hammer Arresters

1. Refer to Section 221000 for Specification.

H. P-Trap Supplies, Stops & Supply Insulation Kits

1. Approved Manufacturers:

    a. Brass Craft.
    b. Dearborn.
    c. McQuire Manufacturing.
    d. PlumberEx.
    e. Truebro.

I. Trap Primers

1. Provide bronze trap primer valve with automatic vacuum breaker, complying with ASSE 1018, with ½" connections matching mating piping system.
2. Acceptable Manufacturers:

    a. Josam Mfg. Co.
    b. MiFab.
    c. Precision Plumbing Products, Inc.
    d. Sioux Chief
    e. Smith (Jay R.) Mfg. Co.
    f. Tyler Pipe; Subs. of Tyler Corp.
    g. Watts Regulator Co.
    h. Zurn Industries, Inc.; Hydromechanics Div.

J. Trap Seals

1. Provide trap guard to floor drain with specified trap seals combination that meets specified floor drain. See drawings for locations.
2. Acceptable Manufacturers:

    a. Sure Seal.
    b. J.R. Smith.

K. Pressure Regulating Valves

1. Provide pressure regulating valves, single seated, direct operated type, bronze body, integral strainer, complying with requirements of ASSE Standard 1003 and lead free. Size for maximum flow rate and inlet and outlet pressures indicated on drawings.
2. Acceptable Manufacturers:

    a. Mueller Mfg. Co.
    b. Watts Regulator Co.
    c. Zurn/Wilkins.

2.04 THERMOSTATIC MIXING VALVE

A. Master Mixing Valve:

1. Provide lead free thermostatic mixing valve or assembly ASSE 1017 listed, to include thermostatic three way mixing valve(s), if required, pressure reducing valve, pressure gauges, union inlet strainer checkstops, dial thermometer, shut-off ball valves and all interconnecting piping. Valve(s) shall provide protection against hot or cold supply line failure and thermostatic failure. Valve(s) shall meet drawing scheduled requirements.

B. Point of Use Mixing Valve

1. Provide lead free thermostatic mixing valve, checkstops, ASSE 1070 listed, and located in a serviceable location.

C. Acceptable Manufacturers:

1. Lawler.
2. Leonard Valve Company.
3. MCC Powers Process Controls.
4. Symmons.
5. Bradley.
6. Watts.

2.05 DIAPHRAGM-TYPE EXPANSION TANKS

A. General: Provide diaphragm expansion tanks of size and number as indicated. Construct tank of welded steel, constructed, tested, and stamped in accordance with Section VIII of ASME Boiler and Pressure Vessel Code for working pressure of 125 psi and lead free. Furnish National Board Form U-1 denoting compliance. Provide specially compounded heavy-duty butyl flexible diaphragm securely sealed into tank to permanently separate air charge from system water, and to maintain design expansion capacity. Provide pressure gauge and air-charging fitting, and drain fitting.

B. Acceptable Manufacturers:

1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett ITT.

2.06 GAS PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion resistant components.
3. Elevation compensator.

B. Pressure Regulators (Service or Line): “Natural Gas” Comply with ANSI Z21.80. Subject to compliance with requirements, provide as indicated on the Drawings.

1. End connections: Threaded for regulators 2” and smaller; flanged for regulators 2-1/2” and larger.
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.

11. Atmospheric Vent: Factory- or field-installed, stainless steel screen in opening if not connected to vent piping. Regulator may include vent limiting device instead of vent connection if approved by authorities having jurisdiction.
12. Maximum Inlet Pressure: See Drawings.
13. Outlet Pressure: See Drawings and Equipment Schedules.
14. Approved Manufacturers:

    a. American Meter Company.
    b. Fisher Control Valves and Regulators; Division of Emerson Process Management.
    c. Itron, Inc.
    d. Pietro Fiorentini

C. Pressure Regulators (Appliance): "Natural Gas" Comply with ANSI Z21.18. Subject to compliance with requirements, provide as indicated on the Drawings.

1. End connections: Threaded for regulators 2" and smaller; flanged for regulators 2-1/2" and larger.
2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Atmospheric Vent: Regulator may include vent limiting device instead of vent connection if approved by authorities having jurisdiction.
8. Maximum Inlet Pressure: See Drawings.
9. Outlet Pressure: See Drawings and Equipment Schedules.
10. Approved Manufacturers:

    a. American Meter Company.
    b. Fisher Control Valves and Regulators; Division of Emerson Process Management.
    c. Maxitrol.
    d. Itron, Inc.
    e. Pietro Fiorentini

2.07 STORM DRAIN, WASTE AND VENT SYSTEM

A. General: Provide pipes and pipe fittings complying with Division 22, Section 221000.

B. Floor Drain, Floor Sinks, Roof Drain, and Vent Flashing: Flashing (safe pan) shall consist of one of the following:

1. 4 lb./ft^2 sheet lead with appropriate under support.
2. No. 24 B & S gauge (.02) sheet copper with 15 lb. asphalt felt sub pans (silver soldered seams only).
3. .04 thickness non plasticized chlorinated polyethylene and asphalted saturated felt flashing as approved and acceptable with jurisdictional code.

C. Drainage Piping Products: 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.

1. Cleanout Plugs: Cast-bronze or brass, threads complying with ANSI B2.1, countersunk head.
2. Floor Cleanouts: Cast-iron body and frame; cleanout plug; adjustable round top as follows:

    a. Nickel-Bronze Top: Manufacturers standard cast unit of the pattern indicated:

        1) Pattern: Exposed flush type, standard non-slip scored or abrasive finish.

3. Grade Cleanouts: Cast-iron body and frame; cleanout plug; adjustable round top as follows:

    a. Cast-iron Top: Manufacturers standard cast unit of the pattern indicated:

        1) Pattern: Exposed flush type, standard non-slip scored or abrasive finish.

4. Wall cleanouts: Cast-iron body adaptable to pipe with cast-bronze or brass cleanout plug; stainless steel cover including screws.
5. Acceptable Manufacturers:

    a. Josam Mfg. Co.
    b. Mifab, Inc.
    c. Sioux Chief.
    d. Smith (Jay R.) Co.
    e. Tyler-Wade.
    f. Watts Co.
    g. Zurn Industries Inc.

D. Drains:

1. General: Provide factory-fabricated drains of size and type indicated. Where not indicated, provide proper selection as determined by Architect/Engineer to comply with installation requirements and governing regulations.
2. Floor Drains and Floor Sinks:

    a. Floor Drain (FD-1): Josam No. 30000-A, cast-iron body, flashing collar, weep holes, satin Nikaloy strainer.
    b. Floor Drain (FD-2): Josam Co. No. 32200, cast iron body, 12-5/8” top, cast iron grate, bottom outlet, weep holes, flashing flange.
    c. Floor Sink (FS-1): Josam No. 49320A-NB-AS, cast iron body, flashing flange acid resisting interior, weep holes, aluminum dome strainer, 12-1/2" square top, 6" deep, 1/2 grate.

3. Roof Drains & Downspout Nozzles:

a. Roof Drain (RD-1): Josam No. 21500-AE-3-22-VP, cast iron body, Leveleze type roof drain, clamp ring w/gravel stop, bottom outlet, deck clamp, sump receiver, cast iron locking dome.
b. Overflow Roof Drain (OD-1): Josam No. 21500-AE-3-16-22-VP, cast iron drain body, Leveleze type overflow roof drain, clamp ring w/gravel stop, bottom outlet, deck clamp, sump receiver, cast iron locking dome, 2" water collar.
c. Downspout Nozzle (DSN-1): Josam #25010 Series, cast bronze downspout nozzle, loose wall flange and inlet threaded connection.
d. Acceptable Manufacturers:

1) Josam Mfg. Co.
2) Mifab, Inc.
3) Sioux Chief.
4) Smith (Jay R.) Mfg. Co.
5) Tyler Pipe; Subs. of Tyler Corp.
6) Watts Co.
7) Zurn Industries, Inc.; Hydromechanics Div.

4. Non-Metallic Trench Drains: Polymer concrete or high density polyethylene, interlocking design with pre-sloped bottom radius.

a. Channel Sections: Interlocking joint, modular units with end caps. Includes flat, round or included bottoms with level, invert and with outlet numbers, sizes and locations.
b. Grates: As indicated in detail on drawings. Channels shall fit recesses in channel sections with no more than 1/8” tolerance to channel or concrete slab.
c. Accessories:

1) Provide manufacturer’s standard supports, anchors, and setting devices.
2) Provide channel-section joining and fastening materials per manufacturer.
3) Provide layout drawings for Engineer/Architect approval. Drawings should show locations, lengths, and installation detail with concrete support, etc.

d. Acceptable Manufacturers:

1) ACO.
2) Jay R. Smith.
3) Mifab, Inc.
4) Poly Drain.
5) Zurn Industries.

2.08 NATURAL GAS SYSTEM

A. General: Provide pipes and pipe fittings complying with Division 22, Section 221000.

B. Natural Gas Specialties:

1. Master Gas Solenoid Control Valve for Kitchen Equipment and BBQ: Aluminum body, packless, single seat, explosion-proof, solenoid operated, normally closed, U.L.-approved, automatic reset, 120-volt. Install master gas solenoid valves in 18- or 20-

gauge stainless steel wall boxes with face plate and access door, as detailed on the drawings.

2. Control Station for Kitchen Equipment and BBQ Master Gas Control Valves: Key operated, pushbutton switch with relay option to de-energize solenoid valve on power loss. Manual reset required. ASCO 108D90C. Furnished and installed by Division 22. Wired by Division 26. All coordination by Division 22.
3. Acceptable Manufacturers:

    a. Automatic Switch Co.
    b. Isimet.
    c. Warrick Control Inc.

2.09 PLUMBING FIXTURES

A. General: Provide factory-fabricated fixtures of type, style and material indicated. Where more than one type is indicated, selection is Installer's option; but, all fixtures of same type must be furnished by single manufacturer.

B. Materials:

1. 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.
2. 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.
3. 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.
4. Stainless Steel Sheets: ASTM A 167, Type 302/304, hardest workable temper.

    a. Finish: No. 4, bright, directional polish on exposed surfaces.

5. 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.
6. Fiberglass: ANSI Z124, smooth surfaced, with color selected by Architect/Engineer.
7. Synthetic Stone: High quality, free from defects, glaze on exposed surfaces, stain resistant.

2.10 PLUMBING FITTINGS, TRIM AND ACCESSORIES

A. General: All components in the plumbing system shall be lead free.

B. 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.

C. P-Traps: Include removable, 17-gauge, chrome plated P-traps with brass nuts, where drains are indicated for direct connection to drainage system.

D. Carriers: Provide cast-iron supports for fixtures of either graphitic gray iron, ductile iron, or malleable iron.

E. Fixture Bolt Caps: Provide manufacturer's standard exposed fixture bolt caps finished to match fixture finish.

F. Escutcheons: Where fixture supplies and drains penetrate walls in exposed locations, provide chrome-plated cast-brass escutcheons with set screw.

G. Aerators: Provide aerators of types approved by Health Departments having jurisdiction.

H. Comply with additional fixture requirements contained in fixture schedule.

I. Faucet/trim shall meet ANSI 117.1 Section 4.20.4.

J. Acceptable Manufacturers:

1. Plumbing Fixtures (Vitreous China):

   a. American Standard; U.S. Plumbing Products.
   b. Kohler Co.
   c. Sloan.
   d. Toto.
   e. Zurn.

2. Lavatory Trim:

   a. American Standard; U.S. Plumbing Products.
   b. Chicago.
   c. Delta.
   d. Kohler Co.
   e. Moen – Commercial.
   f. Zurn Co.

3. Sink Trim:

   a. American Standard.
   b. Chicago.
   c. Delta.
   d. Kohler.
   e. Zurn Co.
   f. Elkay

4. Fixture Seats:

   a. Bemis Mfg. Co.

b. Beneke Corp.
c. Church Products.
d. Kohler Co.
e. Olsonite Corp.; Olsonite Seats.
f. Toto.

5. Electric Water Coolers:

a. Acorn-Aqua.
b. Elkay Mfg. Co.
c. Halsey Taylor Div.
d. Haws Drinking Faucet Co.

6. Mop Basin/Shower Base (Molded Stone):

a. Fiat Co.
b. Florestone.
c. Mustec.
d. Zurn.

7. Stainless Steel Sinks:

a. Elkay Mfg. Co.
b. Just Mfg. Co.
c. Kohler.

8. Shower Trim:

a. Bradley Corp.
b. Delta.
c. Leonard Co.
d. MCC Powers Process Controls.
e. Symmons.

9. Shower Enclosures:

a. American Standard.
b. Aquatic,
c. Aqua-Glass.
d. Kimstock.
e. Kohler.

10. Fixture Carriers:

a. Josam Mfg. Co.
b. Mifab, Inc.
c. Smith Co.
d. Tyler-Wade.
e. Watts Co.
f. Zurn Industries, Inc.; Hydromechanics Div.

2.11 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 is listed in pump schedule. Provide pumps of same type by same manufacturer.

B. In-line Recirculation Pumps:

1. General: Provide in-line recirculation pumps where indicated, and of capacities as scheduled.
2. Type: Horizontal, oil-lubricated, designed for 125 psi working pressure, 225°F (107°C) continuous water temperature, and specifically designed for quiet operation.
3. Body: Bronze or stainless-steel construction.
4. Shaft: Steel, ground and polished, integral thrust collar.
5. Bearings: Two horizontal sleeve bearings designed to circulate oil.
6. Seal: Mechanical, with carbon seal face rotating against ceramic seat.
7. Motor: Non-overloading at any point on pump curve, open, drip- proof, sleeve bearings, quiet operating, rubber mounted construction, built-in thermal overload protection.
8. Coupling: Self-aligning, flexible coupling.
9. Acceptable Manufacturers:

    a. Armstrong Pumps, Inc.
    b. Bell & Gossett ITT; Fluid Handling Div.
    c. Grundfos.
    d. Paco Inc.
    e. Taco, Inc.

2.12 DOMESTIC WATER HEATER

A. Commercial Gas-Fired Water Heaters (Gas-Fired)

1. General: Provide commercial fully condensing design (94% to 99%) gas-fired water heaters of sizes and capacities as indicated on schedule. Provide U.L Listed and meet efficiency requirements of ASHRAE/IES 90.1b-1992. This heater shall be listed by SCAQMD Rule 1146.2 Low NOx.
2. Heater: Construct for working pressure of 160 PSI; boiler type hand hole cleanout; aluminum anode rod; 3/4” tapping for relief valve; glass lining on internal surfaces exposed to water.
3. Controls: the control shall be an integrated solid-state temperature and ignition control device with integral diagnostics, LED fault display capability and a digital display of temperature settings.
4. Direct Venting: The heater(s) shall be suitable for venting PVC, ABS and/or CPVC for sealed combustion direct venting. The heater shall be factory assembled and tested. The power burner shall be of a design that requires no special calibrations on start up. The heater(s) shall be approved for 0” clearances to combustibles.

    a. Freeze protection system having spring loaded damper power to open and spring to close.

5. Jacket: Insulate tank with vermin-proof glass fiber or foam insulation. Provide outer steel jacket with baked enamel finish over bonderized undercoating.
6. Accessories: Provide brass drain valve; 3/4" ASME pressure and temperature relief valve, ASME rated construction and cold-water dip tube or vacuum relief valve (Watts #N36-M1) piped above tank.
7. Provide JJM Boiler Works #JM Series or Axiom #NC-1 Condensate Neutralizing Tube for condensing flues and combustion chambers. Pipe to nearest floor drain.
8. Acceptable Manufacturers:

    a. Bradford – White.
    b. PVI Industries, Inc.
    c. Rheem Water Heater.
    d. Smith Corp. (A.O.); Consumer Products Div.
    e. State Water Heater.

2.13 COMPRESSED AIR SYSTEMS

A. General: Provide pipes and pipe fittings complying with Division-22 Basic Plumbing Materials and Methods section 22 05 00 "Pipes and Pipe Fittings", in accordance with the following listing:

    1. Tube Size 3" and Smaller: Copper tube; hard temper; Type "L"; wrought-copper, soldered-joints.

B. Basic Valves: Provide valves complying with Division-22 Basic Plumbing Materials and Methods Section 22 05 00 "Valves", in accordance with the following listing:

    1. Shutoff Valves:

        a. Ball valves.

C. Basic Meters and Gauges: Provide meters and gauges complying with Division-22 Basic Plumbing Materials and Methods Section 22 05 00 "Meters and Gauges", in accordance with the following listing:

    1. Pressure gauges and fittings.

D. Basic Vibration Control: Provide vibration control products complying with Division-22 Basic Plumbing Materials and Methods section 22 05 00 "Vibration Control", in accordance with the following listing:

    1. Air Compressors:

        a. Fabricate equipment base and spring isolators.

E. Air Compressors:

    1. General: Provide factory-assembled and tested packaged air compressors as indicated, of capacities and having electrical characteristics as scheduled.

2. Type: Provide 2-stage, air-cooled, continuous duty, piston-type motor-driven compressors.
3. The units shall be completely factory prewired and prepiped on a fabricated steel base and ready for single-point connections. Units requiring assembly or wiring of components by the Contractor at job site will not be acceptable, unless specifically required by Contract Documents.
4. Factory package shall consist of two-stage reciprocating, compressor, noncycling refrigerated air dryer, a single vertical ASME labeled receiver with automatic drain and pressure gauge, integral in-line intake filter/muffler, pressure-relief valves, combination unloader and check valves, isolation valves, air cooled aftercooler, drip-proof motors and OSHA/ANSI approved belt guards.
5. All electrical controls shall be housed in a NEMA-12 dustproof cabinet, U.L. approved. Controls shall include fusible disconnect, motor starter, three phase overload protection, control circuit transformers (120V), pressure control switches and hand-off-automatic switch. A thermal malfunction protection device to monitor the running temperature of the compressor shall be provided. This device shall shut down a unit upon sensing an abnormal condition and provide a means of activating a closed-circuit alarm indicating such shutdown.
6. Provide all required accessories for a complete installation. Compressor manufacturer shall pretest the factory package prior to chipping, provide inspection and start-up and maintain a service organization.
7. Manufacturer: Subject to compliance with requirements, provide air compressors of one of the following:

    a. Champion.
    b. Ingersoll-Rand Co.
    c. Quincy Co.

F. Compressed Air Accessories:

1. Compressed Air Receivers: Provide, ASME stamped, cylindrical galvanized steel compressed air receivers, with safety (pressure relief) valves, in sizes, working pressures and temperatures indicated; equip with drain connection.
2. Aftercoolers: Provide air-cooled, fin-tube aftercoolers in capacities and types indicated. Size units for area of cooling surfaces, amount of air delivered, 15°F. maximum approach temperature. Units to be belt guard type or wall mounted, fan cooled type.
3. Air Line Separators: Provide air line separators in sizes and capacities indicated, used for removing water droplets from compressed air. Equip with collecting chamber and float activated discharge valve with drain. Size units for maximum pressure drop through units of 3 psi from air inlet to outlet.
4. Air Line Regulators: Provide spring-opened and pressure-closed air line regulators in sizes and ratings indicated. Equip with poppet valve and hand-operated adjusting screw for setting required pressures.
5. Air Line Filters: Provide two stage, mechanical separation type air line filters in sizes and rating indicated. Equip with deflector plates; resin impregnated ribbon type filters with edge filtration, 40 micro (0.0015") thick; and drain cock.
6. Combination Filter-Silencer/Silencers: Provide weatherproof intake-filter-silencers located where shown and piped to compressor intakes, provide with wire screen cloth type element. Provide intake silencer, tubular type, sized for proper air requirement at compressor intake.

G. Compressed Air Terminal Devices:

1. Compressed Air Quick Coupler Outlets: Provide two-way shut-off type quick detachable couplers with rotating safety sleeve at locations indicated on the drawings. Couplers to be cadmium plated steel construction, 500 PSIG rated with BUNA-N rubber seals.
2. Compressed Air Hose Reels: Provide compressed air hose reels at locations indicated on the drawings. Reels shall consist of 30 coupling, hose stop, 4-roller adjustable guide arm and de-clutching spring hub. Hose end shall be furnished with a double shut-off rotating safety sleeve type quick detachable coupler.
3. Manufacturer: Subject to compliance with requirements, provide compressed air accessories of one of the following:

    a. Balcrank (hose reels).
    b. Foster Co. (quick-couplers)
    c. Graco Co. (hose reels)
    d. Hankison Corporation (dryers)
    e. Hansen Co. (quick-couplers)
    f. Ingerson-Rand
    g. Lincoln (hose reels)
    h. Quincy Co.
    i. Spence Engineering Co., Inc.
    j. Stewart-Warner.
    k. Superior Pneumatic and Mfg., Inc.
    l. Wilkerson Co. (regulators)

PART 3 - EXECUTION

3.01 INSPECTION

A. General: Examine areas and conditions under which piping systems are to be installed. Verify actual locations of equipment, fixtures and/or piping connections prior to installation. Also examine floors and substrates, and conditions under which work is to be accomplished. Correct any incorrect locations of piping, and other unsatisfactory conditions. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF INTERIOR WATER PIPING

A. Install piping level with no pitch.

B. Locate groups of pipes parallel to each other, spaced to permit applying full insulation and servicing of valves.

C. Refer to Section 221000 for hanger and support requirements.

3.03 INSTALLATION OF EXTERIOR WATER PIPING

A. General: Install water service piping system in compliance with local governing regulations.

B. Water Service Piping: Extend water service piping of size and in location indicated to water service entrance at building. Provide sleeve in foundation wall for water service entry; make entry watertight. Provide shutoff valve at water service entry inside building; strainer, pressure gauge, test tee with valve.

3.04 INSTALLATION OF CONDENSATE PIPING

A. Route piping to open waste receptacle (i.e. floor drain, floor sink, mop service basin) or to roof drain, or on to roof or grade per Local Code. If on to grade, do not discharge over walkway.

B. Contractor shall provide acid neutralization tank (container) and all associated flue, boiler and water heater acid condensate connections, including backflow preventer and water connection, as required per the equipment manufacturer. Route piping to acid neutralization vessel and air gap discharge to floor drain or floor sink.

3.05 INSTALLATION OF BACKFLOW PREVENTERS

A. Install backflow preventers where indicated, and where required by governing authority having jurisdiction. Locate in same room as equipment being protected. Pipe relief outlet to nearest floor drain.

3.06 INSTALLATION OF PRESSURE REGULATING VALVES

A. Install pressure regulating valves where indicated. Provide inlet and outlet shutoff valves, and throttling valve bypass. Provide pressure gauge on valve outlet. Refer to details on drawings.

3.07 INSTALLATION OF UNDERGROUND SANITARY DRAIN PIPING WITHIN BUILDING

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. Place plugs in ends of uncompleted piping at end of day or whenever work stops.

B. All soil and waste piping: Shall be run at a slope of not less 1/4" per foot (2.08%) for piping up to 4" in size. All piping 4" and over shall be run at a slope of not less than 1/8" (1.04%) per foot unless noted otherwise on Drawings.

C. Cast-iron Pipe: Install in accordance with applicable provisions of CISPI "Cast Iron Soil Pipe & Fittings Handbook".

D. Polyvinyl Chloride (PVC) Pipe: Install in accordance with manufacturer's installation recommendations, and in accordance with ASTM D2321 (solid core Schedule 40 PVC only).

3.08 INSTALLATION OF ABOVE GROUND STORM AND SANITARY DRAIN, WASTE AND VENT PIPING WITHIN BUILDING

A. General: Install all piping, as indicated and in accordance with the International Plumbing Code.

B. Provide restraints and hangers as appropriate and in accordance with manufacturers recommendations based upon type of pipe, fittings, joints. Refer to Section 221000.

C. Piping shall be run true, plumb, and straight, with all restraints and hangers adjusted to carry their proportional load and locked to prevent pipe "wag", misalignment, movement or shear.

D. Provide anchors for piping risers on every floor using riser clamps, wall brackets, knee brackets, and foot blocks for all vertical piping over 20 feet straight height.

E. All soil and waste piping shall be run at a slope of not less than 1/4" per foot (2.08%) for piping up to 4" in size. All piping 4" and over shall be run at a slope of not less than 1/8" (1.04%) per foot unless noted otherwise on Drawings. All storm drain piping shall be run at slopes indicated on the drawings.

F. Bushings in soil waste or vent piping shall be prohibited. Tapped spigots or tees shall be used when changing from cast iron pipe to DWV waste or vent piping, and for appropriate cleanout plugs.

G. All horizontal storm soil, waste and vent piping shall be supported from the building structure at not more than five (5) foot intervals. Cast iron no-hub pipe and fittings shall be supported within one foot of each side of couplings. All vertical storm soil and vent stacks shall be supported with riser clamps at each floor slab.

H. The waste connections between fixtures and their respective collection and venting systems shall consist of DWV nipples and drainage fittings.

I. All interior waste and vent piping up to 1 1/2" shall consist of DWV copper with drainage fittings. All piping 2" and over shall consist of service weight cast iron soil pipe and fittings.

J. All cast iron pipe and fittings shall have affixed thereon the CISPI grade mark of identification.

K. All vents protruding through the roof shall be not less than 3" size and extended to not less than 12" above the finished roof, and flashed with 24" x 24" x 4 lb. sheet lead. The flashing shall extend not less than 6" above the roof and the edges turned down into a hub type cast iron vent pipe, caulked in place and finished with hot poured lead or per roof membrane manufacturer’s requirements.

L. All vents shall be located in accordance with jurisdictional code and in no case less than two (2) feet from roof edge or parapet, or wall line of an "on the roof structure".

M. Provide all expansion joints, braces, earthquake restraints as required by the contract documents and jurisdictional authority.

3.09 INSTALLATION OF DRAINAGE PIPING PRODUCTS

A. Cleanouts: Install in above ground piping and building drain piping as indicated, as required by International Plumbing Code; and at each change in direction of piping greater that 45 degrees; at minimum intervals of 50' for piping 3" and smaller and 100' for larger piping; and at base of each vertical soil or waste stack. Install floor and wall cleanout covers for concealed piping. Wall cleanouts shall be installed at a maximum height of 1'-6" above finished floor unless otherwise indicated or directed on the plans.

3.10 INSTALLATION OF FLOOR DRAINS AND FLOOR SINKS

A. General: Install floor drains and floor sinks in accordance with manufacturer's written instructions and in locations indicated.

B. Coordinate flashing work with work of waterproofing and adjoining substrate work.

C. Cover all drain strainers during building construction with heavy-duty tape similar to duct tape.

D. Install drains at low points of surface areas to be drained, or as indicated. Set tops of drains flush with finished floor.

E. Install drain flashing collar or flange so that no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes, where penetrated.

F. Provide flashing (safepan) for each floor drain above grade, 24"x24" in size.

3.11 INSTALLATION OF TRAP PRIMERS/TRAP SEALS

A. General: Install trap primers in accordance with manufacturer's installation instructions. Pitch piping towards drain trap, minimum of 1/8" per floor (1%), adjust trap primer for proper flow. Provide trap primers as required by local code authorities and at all floor drains where loss of trap seal due to evaporation exists.

B. Trap seals per manufacturer’s requirements.

3.12 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.

B. Locate piping runouts as close as possible to bottom of floor slab supporting fixtures or drains.

C. Upon completion of installations, flush all traps and fill with water.

3.13 INSTALLATION OF ROOF DRAINS

A. General: Install roof drains in accordance with manufacturer's written instructions and in locations indicated.

B. Coordinate flashing work with work of roofing, water-proofing and adjoining substrate work.

C. Provide flashing (safe pan) for each roof drain, 36" x 36" in size.

D. Coordinate with roofing as necessary to interface roof drains with roofing work.

E. Install roof drains at low points of surface areas to be drained, or as indicated.

F. Install drain flashing collar or flange so that no leakage occurs between roof drain and adjoining roofing. Maintain integrity of waterproof membranes, where penetrated.

G. Position roof drains so that they are accessible and easy to maintain.

H. During application of roofing, plug all roof drains with test plugs, remove plugs after roofing has cured.

I. Securely lock roof drain domes in place upon completion of construction.

3.14 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 governing authority having jurisdiction 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.

3.15 FIELD QUALITY CONTROL FOR FIXTURES

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 Architect/Engineer. Remove cracked or dented units and replace with new units.

3.16 ADJUSTING AND CLEANING OF FIXTURES

A. Clean plumbing fixtures, trim, and strainers of dirt and debris upon completion of installation.

B. Adjust water pressure at drinking fountains, 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.

3.17 INSTALLATION OF NATURAL GAS PIPING

A. Use sealants on metal gas piping threads which are chemically resistant to natural gas. Use sealants sparingly, and apply to only male threads of metal joints.

B. Comply with NFPA 54 and International Gas Code for installation, purging and accidental ignition.

C. Remove cutting and threading burrs before assembling piping.

D. Do not install defective piping or fittings. Do not use pipe with threads which are chipped, stripped or damaged.

E. Plug each gas outlet, including valves, with threaded plug or cap immediately after installation and retain until continuing piping, or equipment connections are completed.

F. Ground gas piping electrically and continuously within project, and bond tightly to grounding connection.

G. Install drip-legs in gas piping where indicated, and where required by code or regulation.

H. Install "Tee" fitting with bottom outlet plugged or capped, at bottom of pipe risers.

I. Use dielectric unions where dissimilar metals are joined together.

J. Install piping with 1/64" per foot (1/8%) downward slope in direction of flow.

K. Install piping parallel to other piping, but maintain minimum of 12" clearance between gas piping and steam or hydronic piping above 200°F (93°C).

L. For risers running through concrete or asphalt, install through pipe sleeve to a minimum of 6" above grade and vent at both ends. Fill annular space with gravel.

M. Install magnesium anodes for underground steel pipe, one-5 lb. anode for up to 100' in length and one-5 lb. anode for each additional 100'.

N. Install magnesium anodes for each underground steel or malleable- iron fitting, isolated between 2 sections of plastic pipe; one-3 lb. anode for each fitting.

O. For underground piping, provide insulating flange or union above ground prior to entering building above grade.

P. Refer to Section 221000 for hanger and support requirements.

3.18 GAS SERVICE

A. General: Arrange with Utility Company to provide gas service to building including gas meter, regulator, service shut-off valve, and gas load within 30 days after award of contract. Consult with Utility as to extent of its work, costs, fees and permits involved. Pay such costs and fees; obtain permits. Costs for actual installation of service and setting of meter by the utility company shall be paid by the owner. Coordinate size of concrete pad or wall brackets for utility company to set meter.

B. Extend building service line from gas meter into building. Provide full size plug valve on downstream side of meter. Enter building at a minimum of 12" above grade.

3.19 INSTALLATION OF VALVES

A. Gas Cocks: Provide at connection to gas train for each gas-fired equipment item; and on risers and branches where indicated.

B. Locate gas cocks where easily accessible, and where they will be protected from possible injury.

C. Pressure Regulating Valves: Install as indicated; comply with Utility requirements. Pipe atmospheric vent to outdoors, full size of outlet. Install gas shutoff valve upstream of each pressure regulating valve.

D. Verify venting requirements for pressure regulating valves in factory installed or factory supplied valve trains. Extend atmospheric vent to outdoors, full size of vent outlet when equipment is controlled by spark ignition. When equipment has standing pilot, pipe regulator vent(s) to combustion chamber. Verify regulator venting requirements with local authority prior to installation.

3.20 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. Install in-line pumps, supported from piping system.

3.21 ADJUSTING AND CLEANING OF PUMPS

A. Alignment: Check alignment, and where necessary, realign shafts of motors and pumps within recommended tolerances by manufacturer.

B. Start-Up: Lubricate pumps before start-up. Start-up in accordance with manufacturer's instructions.

3.22 INSTALLATION OF WATER HEATERS

A. General: Install water heaters in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances. Provide heat traps per Code on all water heaters.

B. Support: Place units on concrete pads, orient so controls and devices needing service and maintenance have adequate access.

1. Flue: Connect flue to draft hood with gas-tight connection. Provide flue of minimum size as flue outlet on heater. Comply with gas utility requirements.

3.23 EXPANSION TANK

A. Install expansion tank in accordance with manufacturer’s recommendations.

B. Provide unions and ball valves for complete isolation of the tank from the system.

C. Charge tank with proper air charge as recommended by manufacturer.

D. Tank tappings shall be provided as detailed or appropriate, ASME welded tank flanges or nipples.

E. Suspend tank from building structure.

3.24 FIELD QUALITY CONTROL FOR COMPRESSED AIR SYSTEMS

A. Compressed Air Piping Leak Test: Prior to initial operation of piping system air purge lines with oil-free dry air, and perform 24-hour standing pressure time-test. Charge line with compressed air to 150 psi; maintain test pressure for 24-hours. During pressure test, test joints and fittings for leaks with soap bubble solution; while bubble testing, hammer joints with rubber or rawhide mallet to break hardened flux.

B. Repair or replace compressed air piping as required to eliminate leaks, and retest as specified to demonstrate compliance.

C. Cap (seal) ends of piping where not connected to mechanical equipment.

END OF SECTION 222000

SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.01 DESCRIPTION OF SYSTEMS

A. Division 23 includes but is not limited to:

1. Section 230500 – Common Work Results for HVAC.
2. Section 230548 – HVAC Vibration Control.
3. Section 230553 – HVAC Identification.
4. Section 230593 – Testing, Adjusting and Balancing.
5. Section 230700 – HVAC Insulation.
6. Section 230923 – Temperature Control Systems – DDC.
7. Section 230993 – Sequences of Operations.
8. Section 232000 – HVAC Pipes, Valves and Pipe Specialties.
9. Section 232100 – HVAC Hydronic Systems.
10. Section 232300 – Refrigerant Piping Systems
11. Section 233000 – Air Distribution.
12. Section 235200 – Heat Generation.
13. Section 235500 – Fuel Fired Heaters.
14. Section 237302 – Packaged Rooftop Air Handling Units.

1.02 DESCRIPTION OF WORK

A. Work Included: Unless specified otherwise, provide all supervision, labor, materials, transportation, equipment, hauling, and services necessary for a complete and operational HVAC system. Provide all incidental items such as offsets, fittings, etc. required as part of the work even though not specifically shown on Contract Drawings or Specifications.

B. Requests for Information: See Section 012000 – Price and Payment Procedures – Modification Procedures, for required research of Contract Documents and subsequent documentation of noted issues through requests for information.

C. Types of mechanical related work specified in this section include the following:

1. Motors.
2. Starters.
3. Access Doors.
4. Variable Frequency Drives.
5. Temporary Heat.
6. Cutting and Patching

1.03 SUBMITTALS

A. Provide the following submittals:

1. Motors
2. Starters
3. Access Doors.
4. Variable Frequency Drives

1.04 REFERENCES

A. See Section 014000 - Quality Requirements - References and Standards, for references to documents and standards.

B. For products or workmanship specified by Association, Trade or Federal Standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.

C. The date of the standard is that which is in effect as of the date of the Contract Documents, except when a specific date is specified.

1.05 QUALITY CONTROL

A. See Section 014000 – Quality Requirements, for quality control requirements.

B. Materials and apparatus required for the HVAC scope of work shall be new and of first-class quality. Erected, connected and finished in every detail, and selected and arranged so as to fit properly into the building spaces.

C. Unless otherwise specifically indicated, equipment and materials shall be installed in accordance with the recommendations of the manufacturer. This includes the performance of tests as recommended by the manufacturer.

1.06 EXAMINATION OF CONTRACT DRAWINGS AND SPECIFICATIONS

A. The HVAC Drawings show the general arrangement of piping, ductwork, HVAC equipment, and appurtenances, and shall be followed as closely as actual building construction and the work of other trades will permit.

B. The Architectural and Structural Drawings shall be considered part of the HVAC work insofar as these Drawings furnish this Division with information relating to design and construction of the building.

C. Field verify building dimensions governing HVAC work. Do not scale the HVAC Drawings for dimensions.

D. The HVAC Contractor shall request of the Test and Balance (TAB) Contractor an early review of the Contract Documents for the purpose of identifying where proper balancing cannot be achieved. The report requirements are specified in Division 23, Section 230593, Testing, Adjusting and Balancing, “Submittals.” Forward a copy of the report to the HVAC engineer for review. The HVAC Contractor shall modify the system as recommended by the TAB Contractor or refer unresolved issues to the HVAC Engineer for resolution prior to ordering of

ductwork and equipment. Unresolved balancing issues from untimely or incomplete application of these requirements shall be corrected in the field at no extra cost to the project.

E. Discrepancies:

1. Examine Drawings and Specifications for other parts of the work, and if any discrepancies occur between the drawings for the work of this Division and the plans for the work of others. Report such discrepancies as a request for information following the procedure outlined in Section 012000.
2. Should there be a conflict in dimensions or locations between the HVAC Drawings and/or Architectural/Structural Drawings, report such discrepancies as a request for information following the procedure outlined in Section 012000.

1.07 REGULATORY REQUIREMENTS

A. See Section 014100 – Regulatory Requirements, for applicable codes and regulations in addition to the following.

1. 2015 International Building Code.
2. 2015 International Mechanical Code.
3. 2015 International Energy Conservation Code.
4. 2015 International Fire Code.

B. Where hourly fire and smoke ratings are indicated or required, whether or not shown, provide components and assemblies meeting requirements of the American Insurance Association, Factory Mutual Insurance Association and listed by Underwriters Laboratories, Inc.

1.08 COORDINATION

A. See Section 013114 – Facility Services Coordination, for coordination requirements and procedures between all applicable construction trades.

B. Before purchase, fabrication, or installation of HVAC components, determine if the installation will properly fit and can be installed as contemplated without interference with structural elements or the work of other trades.

C. Locations of pipes, ducts, switches, panels, equipment, and fixtures, shall be adjusted to accommodate the work or interferences anticipated and encountered. Determine the exact route and location of each pipe and duct prior to fabrication.

D. Right of Way: Lines which pitch shall have the right-of-way over those which do not pitch. Lines whose elevations cannot be changed shall have right-of-way over lines whose elevations can be changed.

E. Offsets, transitions and changes in direction of pipes and ducts shall be made as required to maintain proper head room and pitch of sloping lines whether or not indicated on the Drawings.

F. Where major conflicts occur, contractor shall rely upon the Architect/Engineer to make final decision regarding priority of right-of-way. Prior to installation or removal of components in

conflict, report any such conflicts as a request for information following the procedure outlined in Section 012000.

G. When directed by the Architect/Engineer, submit Coordination Drawings showing interrelationship of various portions of work and work of other trades. Failure to properly coordinate may result in removal and relocation at expense to the Contractor.

H. Three-Dimensional Coordination Documents for Acoustical and Drywall Ceilings, Plumbing, Fire Protection, HVAC and Electrical, shall be provided in accordance with requirements listed in Section 013114 – Facility Services Coordination.

I. Coordination Drawings for Acoustical and Drywall Ceilings, Plumbing, Fire Protection, HVAC and Electrical:

1. Coordination Drawings are required for the trades noted above. The HVAC contractor shall prepare reproducible Coordination Layout and Installation Drawings (at least ¼" scale or as approved by the Architect) for resolution of interferences and conflicts with other trades.
2. The Plumbing, Fire Protection and Electrical Contractors, as well as acoustical and drywall ceiling contractors, are required to superimpose their Shop Drawings on the HVAC Drawings and verify layout and elevations to eliminate conflicts. Any conflicts shall be highlighted and these Drawings shall be forwarded to the Architect for resolution. Priority shall be given to "gravity" systems above the ceiling. Each trade shall initial acknowledgement that the proceeding has been completed. No fabrication of ductwork, fire protection, or other prefabricated systems shall begin until these Coordination Drawings have been completed and reviewed by the General Contractor and Architect/Engineers. Any Subcontractor that fabricates and installs items above the ceiling before the Coordinated Drawings are reviewed and conflicts resolved shall do so at their own risk, and be responsible to relocate said equipment in the event conflicts arise, at no cost to the Owner.
3. Additionally, all trades shall show the proposed location of access panels (for maintenance) in "hard" ceilings for access to HVAC boxes, control valves, fire damper motors, plumbing valves, fire protection drains, valves, light fixture remote ballasts, ceiling hung equipment, etc., for coordination with the reflected ceiling plans. Indicate on same Drawings the location of access panels in walls as well as location of plumbing cleanouts.

J. Upon Architect/Engineer completion of the review of the Coordination Drawings, the Design Team, General Contractor and Subcontractors shall conduct a pre-installation coordination meeting for all "fit-up" above ceilings. No ceiling shall be lowered without the expressed approval of the Owner and the Architect

K. Coordinate all cutting & patching, provide cutting and patching per Section 017000.

L. Utility Interruptions: Coordinate HVAC utility interruptions per Section 017000.

1.09 PROJECT CONDITIONS

A. Accessibility:

1. Contractor shall be responsible for the sufficiency of the size of shafts and chases and the adequate clearance in double partitions and hung ceilings for proper installation of work. Such spaces and clearances shall be kept to the minimum size required.
2. Locate all equipment which must be serviced, operated, or maintained in fully accessible positions. Furnish access doors for this purpose. Minor deviations from Drawings may be allowed to provide for better accessibility. Any changes shall be approved by the Architect prior to making the change.
3. Determine the exact locations of access doors. Locations of these doors shall be submitted in sufficient time to be installed in the normal course of work.
4. Demonstration of access will be required prior to project completion. The contractor is responsible for providing reasonable and safe access for all system components. HVAC Contractor to demonstrate access and serviceability of all equipment to Owner.

B. Fabrication: Before any ductwork is fabricated and before installing and/or fabricating any lines of piping or ductwork the Contractor shall assure himself that they can be run as contemplated in cooperation with Contractors of other Divisions of the Work and the physical constraints of the Structural and Architectural Work.

C. Freeze Protection: Do not run pipes in outside walls, or locations where freezing may occur. Piping next to outside walls shall be in furred spaces with insulation between the piping and the outside wall. Insulation of piping shall not be considered freeze protection.

D. Scaffolding, Rigging and Hoisting: Provide scaffolding, rigging, hoisting and services necessary for erection and delivery into the premises of any equipment and apparatus furnished. Remove same from premises when no longer required.

1.10 SUBMITTALS:

A. See Section 013000 – Administration Requirements, for submittal procedures.

B. The review comments of the Architect and/or Engineer do not in any case supersede the Drawings and Specifications, and shall not relieve the Contractor from responsibility for deviations from the Drawings or Specifications unless the Contractor has called to the attention of the Architect and/or Engineer, in writing, such deviations at the time of submission, nor shall it relieve the Contractor from responsibility for errors of any sort in the items submitted.

C. Deviations: It is the contractor's responsibility to indicate deviations from the Plans and Specifications. Approval shall not be considered acceptance of the deviation unless it has been explicitly indicated.

1.11 FIELD REPORTS

A. During the construction period the Engineer may issue periodic field reports. The contractor shall immediately address the issues and provide a written response.

B. The written response must be returned to the Architect no later than (5) working days after receipt of the site observation report.

1.12 PRODUCT OPTIONS AND SUBSTITUTIONS

A. Substitutions: See Section 016000 – Product Requirements, for substitution procedures applicable to all products specified in Division 23.

B. Substitution requirements listed in Section 016000 apply to any "acceptable manufacturer" that is not the basis of design. Manufacturers specifically shown on the equipment schedules shall be considered the basis of design; the basis of design for unscheduled equipment shall be as noted in the associated specification section.

C. When alternate or substitute materials and equipment are used, Contractor will be responsible for space requirement, configurations, performance, changes in bases, supports, structural members and openings in structure, electrical changes and other apparatus and trades that may be affected by their use. Contractor shall provide drawings for alternate/substitute equipment in detail equal to the construction documents.

1.13 PROJECT RECORD DOCUMENTS

A. See Section 017800 – Closeout Submittals, for submittal requirements and procedures.

1.14 ELECTRIC WIRING AND SAFETY DEVICE WORK AND MATERIAL RESPONSIBILITIES

A. Unless otherwise indicated, all HVAC equipment motors and controls shall be furnished, set in place, and wired in accordance with the following schedule: MD = HVAC Division, ED = Electrical Division, TD = Temperature Control Division, I = Installer of equipment requiring electrical service.

B. Note: If Temperature Control Division is a subcontract to the HVAC Contractor, both MD and TD shall fall under the responsibility of MD. If no Temperature Control Contractor is under contract, MD shall assume all Temperature Control responsibilities.

	Furnished Under	Set In Place or Mounted Under	Power Wired & Connected Under	Control Wired & Connected Under
1. Other Equipment Motors/Starters	I	I	ED	I
2. HVAC Equipment Motors	MD	MD	ED	TD
3. HVAC Magnetic Motor Starters, VFD's	MD	MD	ED	TD
4. Control Wiring Regardless of Voltage	TD	TD	TD See footnote 1	TD
5. Control Components: Control Relays, Thermostats, Control Transformers, EP, PE Switches	TD	TD	TD See footnote 1	TD
6. Temperature Control Panels, Time Clocks, Controllers	TD	TD	TD See footnote 1	TD
7. Valve and Damper Motors and Actuators	TD	TD	TD See footnote 1	TD

	Furnished Under	Set In Place or Mounted Under	Power Wired & Connected Under	Control Wired & Connected Under
8. Control Valves, Solenoid Valves	TD	MD	--	TD
9. Control Dampers Integral with a Fan Unit	MD	MD	--	--
10. Control Dampers (duct mounted)	TD	MD	--	TD
11. Thermowells in Piping	TD	MD	--	--
12. Smoke Duct Detectors (including relays)	ED See footnote 3	MD See footnote 3	ED See footnote 4	ED See footnote 3
13. Fire and Smoke Dampers	MD	MD	ED	ED See footnote 2
14. Pushbutton Stations and Pilot Lights	MD	MD	ED	TD See footnote 4
15. Manual Operating Switches	MD	MD	ED	-- See footnote 5
16. Multi-speed Switches (not integral with Equipment served)	MD	MD	ED	-- See footnote 5
17. Fused and Unfused Disconnect Switches & Thermal Overload Switches	ED See footnote 6	ED See footnote 6	ED	--
18. Contactors	ED	ED	ED	ED
19. Temporary Heating Connection	MD	MD	ED	TD
20. Boiler Controls, Boiler Burner Control Panels Internally Wired	MD	MD	TD See footnote 1	TD

1. Footnote 1: It is the intention of this specification for all conduit and wiring which connects to control equipment or provides controls to HVAC equipment to be provided by the Temperature Control Contractor. Other portions of the specification which may be in conflict with this concept shall be brought to the attention of the engineer for clarification prior to bidding the project. The ED shall provide line voltage wiring conduit and junction boxes for the express purpose of temperature controls. It shall be the responsibility of the Temperature Control Contractor to coordinate the location of the junction boxes (if not otherwise shown on the Electrical Drawings) and to utilize these junction boxes for temperature control wiring. The Temperature Control Contractor shall extend line and/or low voltage wiring from junction boxes to all HVAC and control components which require control wiring.
2. Footnote 2: Wiring from the fire alarm electrical contacts to fire alarm system control panel by ED; all HVAC equipment control function wiring by TD. ED to coordinate locations of electrical contact with MD. MD to coordinate locations of duct smoke detectors with ED.
3. Footnote 3: MD shall assist in locating the detectors, but ED shall verify that the installation meets the manufacturer's installation guidelines, and is responsible for correctly ordering the smoke detectors. MD shall mount the detectors in a manner directed by ED according to manufacturer's recommendation. If the detector is used for operation of a smoke/fire damper, the control wiring will be by ED. If the unit is used for fan shutdown, the fire alarm functions will be by ED and the wiring to the starter or VFD for a direct shutdown will be by MD, typically by the TD. Any signal required for the sequence of operation shall be coordinated between MD and ED, with ED providing a point of connection and MD responsible for the remainder of the installation.

4. Footnote 4: For connection to auxiliary contacts if required.
5. Footnote 5: Device is used in the power wiring circuit to the equipment. Control functions do not exist.
6. Footnote 6: Unless furnished with equipment.

C. Provide Division 26 with a complete summary list of all HVAC equipment requiring electric power prior to within 30 days after award of contract. This list shall summarize equipment power loads, line voltage control requirements, quantities, and locations of equipment and connection points. If any HVAC equipment is required to run on emergency power, the list shall note that requirement along with the requirement for the building temperature controls systems to also be on emergency power.

1.15 DELIVERY, STORAGE AND HANDLING

A. See Section 016000 – Product Requirements, for delivery, storage and handling requirements.

1.16 WARRANTIES

A. See Section 017800 – Closeout Submittals, for general warranty requirements.

1.17 SCHEDULE OF TESTING

A. See Section 014533 – Code Required Special Inspections, for testing requirements and procedures.

B. Make all specified tests on piping, ductwork and related systems as necessary. Demonstrate the proper operation of equipment installed under this project.

C. Equipment shall not be tested, or operated for any purpose until fully lubricated in accordance with manufacturer's instructions and until connections to fully operative systems have been accomplished.

D. A schedule of testing shall be in such a manner that it will show areas tested, test pressure, length of test, date, time and signature of testing personnel. All testing must be performed in the presence of the Contractor's representative; his signature for verification of the test must appear on the schedule. At completion of testing, the schedule shall then be submitted in triplicate to the Architect.

E. Make sure operational and performance tests are made on seasonal equipment.

1.18 KEYS

A. Keys: Upon completion of work, submit keys for HVAC equipment, panels, etc. to the General Contractor.

1.19 OPERATING AND MAINTENANCE DATA

A. See Section 017800 – Execution and Closeout Requirements, for Operating and maintenance Manual requirements.

1.20 INSTRUCTIONAL SESSIONS

A. See Section 017900 - Demonstration and Training, for all instruction session requirements. Both HVAC Contractor and Temperature Controls Contractor to provide separate training on respective systems per this section.

PART 2 - PRODUCTS

2.01 MOTORS

A. Motor Characteristics: Except where more stringent requirements are indicated, comply with the following requirements for motors of mechanical work:

1. Temperature Rating: Rated for 104°F (40°C) environment with maximum 122°F (50°C) temperature rise for continuous duty at full load (Class A Insulation).
2. Altitude Deration: Motors to be furnished to maintain specified rated service factor at altitude of project.
3. Starting Capability: Provide each motor capable of making starts as frequently as indicated by automatic control system, and not less than 5 starts per hour for manually controlled motors.
4. Phases and Current Characteristics: Provide squirrel-cage induction polyphase motors for 3/4 hp and larger. Provide capacitor-start single-phase motors for 1/2 hp and smaller; except 1/6 hp 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 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.
5. Power Factor: All motors rated greater than 1000 watts shall have a Power Factor of not less than 85% under rated load conditions. The 85% PF may be obtained by design of the motor or by providing a capacitor. Capacitors, if provided to obtain the 85% PF, must be switched with the motor. If the motor draws less than 1000 watts at full load, it is excluded from the 85% power factor requirement.
6. Efficiency: Motor efficiency ratings shall conform to NEMA Standard MG-1-2011.
7. Service Factor: 1.15 for three-phase motors and 1.35 for single-phase motors.
8. VFD Compatible: All three-phase motors shall be inverter duty for use with a VFD.

B. Motor Construction: Provide general purpose, continuous duty motors, Design "B" or "C" where required for high starting torque. Provide inverter duty motors, for all variable speed motor applications:

1. Frames: NEMA No. 56.

2. Bearings: Ball or roller bearings with inner and outer shaft seals, regreasable except permanently sealed where motor is normally inaccessible for regular maintenance. Provide double shielded ball bearings in accordance with ANSI-B 3.16-1972.
3. 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.
4. 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.
5. Overload Protection: Provide built-in thermal overload protection and, where indicated, provide internal sensing device suitable for signaling and stopping motor at starter.
6. Noise Rating: Provide "Quiet" rating on motors. Motors shall not exceed 80 DB at full speed and power.
7. Shaft Grounding Kits: Provide shaft grounding rings for all 3-phase motors with variable frequency drives as called out on the plans.

C. Name Plate: Provide metal nameplate on each motor, indicating full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

D. Manufacturer: Except where item of mechanical equipment (which otherwise complies with requirements) must be integrally equipped with motor produced by another manufacturer, provide motors for mechanical equipment manufactured by one of the following:

1. Allis-Chalmers Corp.
2. Baldor Electric Co.
3. Century Electric Div., Inc.
4. General Electric Co.
5. Louis Allis Div.; Litton Industrial Products, Inc.
6. Marathon Electric Mfg. Corp.
7. Reliance Electric Co.
8. Westinghouse Electric Corp.

2.02 STARTERS

A. Motor Starter Characteristics: Comply with NEMA standards and NEC. Provide enclosures NEMA Type as required with padlock ears, and with frames and supports for mounting on wall, floor or panel **as indicated**. Where starter location is not within sight of motor, provide fused disconnect switch within sight of motor. Provide type and size of starter recommended by motor manufacturer and equipment manufacturer for applicable protection and start-up condition; refer to individual equipment sections for basic load requirements.

1. Manual Switches: Provide manual switch and pilot light for motors 1/2 hp and smaller, except where interlock or automatic operation is indicated. **Provide extra switch positions and pilot lights for multi-speed motors.**

a. Overload Protection: Provide melting alloy type thermal overload relays.

2. Magnetic Starters: Provide magnetic starters for motors 3/4 hp and larger, and for smaller motors where interlock or automatic operation is indicated. Include the following:

   a. Heavy-duty oiltight type hand-off-auto switch and pilot lights, properly arranged for single-speed operation as indicated.
   b. Trip-free thermal overload relays, each phase.
   c. Built-in 120-volt control circuit transformer, fused from line side and on secondary side.
   d. Control circuit conductors to be protected in accordance with Article 250-5, Exception 5, of the National Electric Code.
   e. Externally operated manual reset.
   f. Undervoltage release or protection.
   g. Hand-off-auto switch.
   h. Single Phasing Protection: All starters shall include a phase protection relay mounted and wired in the starter enclosure, equal to time-mark 257 series or motor saver model 201. Starters for motors 5 hp and less may meet this requirement either by supplying the phase protection relay as above, or by providing a current differential trip mechanism in the overload relay which advances the trip setting 25% or more under single phase conditions. Submittals must include documentation of the type of single phasing protection is used.
   i. Provide spare normally open and normally closed contacts.
   j. With two speed starters, include an adjustable time delay device within starter enclosure to allow the motor to come to a complete stop when switching from high to low speed. Two speed starters shall have heavy duty 4 position rotary switch, "auto-off-low-high".

B. Weather Protection: Provide weather-proof mounting of magnetic starters for equipment outside of the building.

C. Unless furnished otherwise, provide over current protection for each motor. Coordinate with Division 26.

D. Motor Starter Manufacturer: Provide motor starters for mechanical equipment manufactured by one of the following:

   1. ABB.
   2. Allen-Bradley Co.
   3. Cutler-Hammer, Inc.
   4. General Electric Co.
   5. Sprecher & Schuh.
   6. Square D Co.
   7. Westinghouse Electric Co.

2.03 ACCESS DOORS

A. See Section 083100 – Access Doors and Panels, for access door product requirements.

2.04 VARIABLE FREQUENCY DRIVES

A. Provide a variable-speed adjustable-frequency drive system, fully tested by the manufacturer before shipment. Start-up services shall be provided by the manufacturer at the installation site for inspection and adjustment. Submit a complete wiring diagram for approval by the Engineer.

B. Warranty: The drive system shall be warranted by the manufacturer for a period of 36 months from date of shipment.

C. Provide a Variable Frequency Drive (VFD) for each piece of mechanical equipment (fan or pump) as noted on the drawings. All variable frequency drives shall be provided with a NEMA 1 enclosure unless indicated otherwise.

1. The adjustable frequency controller shall be solid state type and performance matched to the energy efficient motor.
2. The adjustable frequency controller shall convert 480 volt, +10 to -5%, three phase, A-C power for stepless motor control from 10% to 110% of base speed. All components shall mount within the adjustable frequency controller enclosure unless otherwise specified.
3. The VFD and components shall be UL listed. The AFC shall comply with the applicable requirements of the latest standards of ANSI, IEEE and the National Electric Code.
4. The VFD shall be designed and constructed to operate within the following service conditions:

    a. Elevation: to **3,300 OR 4,700** feet above sea level without derating.
    b. Ambient Temperature Range: 32°F - 104°F (0° - 40° C).
    c. Atmosphere: non-condensing relative humidity to 95%.
    d. A-C Line Voltage Variation: 5% to 10%.
    e. A-C Line Frequency Variation: +2 Hz.

5. The VFD individual enclosures shall be NEMA 1 – Indoor Non-Hazardous, with hinged front door and line circuit breaker with double lugs and side openings for Cross Bus Cables. Cabinets shall be factory prewired and assembled.
6. Each VFD shall have the following basic features:

    a. On/Off switch.
    b. Auto/Manual switch.
    c. Speed selection.
    d. Hz controlled speed range.
    e. Auxiliary contacts for remote indication of VFD fault condition and on-off status.
    f. Start-stop and speed selection with coast-to-rest standard or ramp-to-rest by jumper selection on "stop".
    g. Input fuses or breakers.
    h. Insensitive to incoming power phase sequence.
    i. Acceleration/Deceleration control adjustable over range of 2 to 180 seconds by separate ramps.
    j. Adjustable volts/hertz and adjustable voltage boost.
    k. Output frequency stabilized to +0.5% of set speed for +10% to -5% change in line voltage or 59°F (15°C) change in ambient temperature.
    l. Three-phase output voltage regulated at +1% of rated voltage with +10% to -5% variations in plant power.

m. Automatic shutoff under output short circuit conditions or when load current can damage the drive.
n. Line transient protection prevents power line transients from harming the controller.
o. Provisions for remote start-stop, and speed control.
p. Monitor lamps for each power stage provide immediate indication of drive functioning.
q. A circuit breaker providing a positive disconnect on all 3 phases of the incoming A-C line. The circuit breaker shall be mounted inside the controller enclosure and include a mounting bracket and through-the-door interlocking handle with provisions for padlocking:

    1) Circuit breakers shall be thermal magnetic molded case current limiting type.

r. Thermal overload relay designed to protect one A-C motor, operated on VFD output from extended overload operation.
s. Shall enable the AFC to follow a 0-5, 1-5, 4-20, 10-50, ma; 0-4, 0-8, 0-10, VC-C grounded or ungrounded signal from a process controller and shall permit operation of the controller over and 11:1 speed range.
t. Shall provide a positive disconnect or contactor between the output terminals of the VFD controller and the motor being controlled. When a VFD stop command is initiated, the contactor shall immediately open if coast-to-rest operation is selected. If ramp-to-rest operation is selected, the VFD, upon stop command, shall first bring the motor to a controlled stop after which the contactor drops out. In either mode of operation, when start command is initiated, the contactor shall first close before the VFD converter or invertor sections begin operation.
u. An automatic restart upon return of power shall be provided when in auto mode.

PART 3 - EXECUTION

3.01 INSTALLATION OF MOTORS AND STARTERS

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 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. Install starters and wiring devices securely supported and anchored, and in accordance with manufacturer's installation instructions. Locate for proper operational access, including visibility, and for safety.

C. Install control connections for motors to comply with NEC and applicable provisions of Division 26 sections.

3.02 ACCESS TO MECHANICAL WORK

A. Installation:

1. Provide access doors for installation and provide instructions for their location. Exact location of access doors to be as directed by HVAC Contractor and Architect/Engineer.
2. Furnish all access doors whether shown or not.
3. Comply with manufacturer's instructions for installation of access doors.
4. Coordinate installation with work of other trades.
5. Set frames accurately in position and securely attach to supports with face panels plumb or level in relation to adjacent finish surfaces.
6. Access door location shall be coordinated with Architect/Engineer prior to installation. All access panels not coordinated will run the risk of removal and relocation at the expense of the contractor.
7. Install access doors for the following concealed equipment:

    a. Manual volume dampers.
    b. Valves.
    c. Control devices.
    d. Fire dampers and fire/smoke dampers.
    e. Coils.
    f. Other mechanical equipment requiring service.

B. Adjust and Clean:

1. Adjust hardware and panels after installation for proper operation.
2. Remove and replace panels or frames that are warped, bowed, or otherwise damaged.

3.03 INSTALLATION OF VARIABLE FREQUENCY DRIVES

A. General: Install variable frequency drive systems in accordance with the manufacturer's instruction.

B. 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.
2. Examination:

    a. Contractor to verify that job site conditions for installation meet factory recommended and code-required conditions for VFD installation prior to start-up, including clearance spacing, installation of the motor wiring, and installation per the manufacturer's recommendations shall be verified.
    b. The VFD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The VFD shall not be operated while the unit is covered.

3. Start-up Service:

a. The manufacturer shall provide start-up commissioning of the VFD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified shall not be acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system.

3.04 HEATING AND COOLING SYSTEMS USED FOR TEMPORARY CONDITIONING DURING CONSTRUCTION

A. Permanent heating and cooling systems shall not be used unless approved in writing.

B. If for any reason a mechanical system has been placed into operation, it shall not be shut down except for moderate weather, and all heated areas shall be maintained at a minimum temperature of 50°F, 24 hours a day. Building must be totally enclosed; no temporary barriers.

C. When any air-handling equipment is used for temporary conditioning, the filters shall be installed and maintained. Before building acceptance by Owner, these units shall be thoroughly cleaned and new filters shall be installed. This is over and above the set of filters to be provided the Owner as called for in the specifications. Coils shall be cleaned if necessary, as determined by the Architect or Engineer:

1. Any and all systems being used for temporary conditioning shall become the contractor's responsibility to maintain, and be put into first class working order before acceptance by the Owner.
2. Any guarantees that start with the use of equipment for temporary conditioning shall be personally extended by the contracting firm holding the prime contract for construction, so that the Owner will have fully specified warranty from date of acceptance.

END OF SECTION 230500

SECTION 230548 - HVAC VIBRATION CONTROL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Refer to Section 230500 – Common Work Results for HVAC – Submittals for requirements related to the Seismic Restraint Plan to be submitted by the contractor.

PART 2 - PRODUCTS

2.01 VIBRATION CONTROL MATERIALS AND SUPPORT UNITS

A. Fiberglass Pads and Shapes: Glass fiber of not more than 0.18 mil diameter, produced by multiple-flame attenuation process, molded with manufacturer's standard fillers and binders through 10 compression cycles at 3 times rated load bearing capacity, to achieve natural frequency of not more than 12 Hertz, in thicknesses and shapes required for use in vibration isolation units.

B. Neoprene Pads: Oil-resistant neoprene sheets, of manufacturer's standard hardness and cross-ribbed or waffled pattern.

C. Vibration Isolation Springs: Wound-steel compression springs, of high-strength spring alloy steel; with spring diameter not less than 0.8 of compressed height of spring at rated loads. Provide minimum additional travel to solid, equal to 50% of rated deflection. Provide spring wire with elastic limit stress exceeding stress at solid deflection.

D. Pad-Type Isolators: Except as otherwise indicated, provide manufacturer's standard pad-type isolation unit, fiberglass pads or shapes, or neoprene pads.

E. Neoprene Mountings: Provide neoprene mountings consisting of neoprene element bonded between 2 steel plates that are neoprene- covered to prevent corrosion. Provide minimum rated deflection of 0.35". Provide threaded hole in upper plate and 2 holes in base plate for securing to equipment and to substrate.

F. Spring Isolators, Free-Standing: Except as otherwise indicated, provide vibration isolation spring between top and bottom loading plates, and with pad-type isolator bonded to bottom of bottom loading plate. Include studs or cups to ensure centering of spring on plates. Include leveling bolt with lock nuts and washers, centered in top plate, arranged for leveling and anchoring supported equipment as indicated.

1. Include holes in bottom plate for bolting unit to substrate as indicated.

G. Isolation Hangers: Hanger units formed with brackets and including manufacturer's standard compression isolators of type indicated. Design brackets for 3 times the rated loading of units. Fabricate units to accept misalignment of 15 degrees off center in any direction before

contacting hanger box, and for use with either rod or strap type members, and including acoustical washers to prevent metal-to-metal contacts.

1. Provide vibration isolation spring with cap in lower part of hanger and rubber hanger element in top, securely retained in unit.
2. Provide neoprene element, with minimum deflection of 0.35", securely retained in hanger box.
3. Provide fiberglass pad or shape, securely retained in unit, with threaded metal top plate.
4. Provide hangers, precompressed to rated load to limit deflection during installation. Design so hanger may be released after full load is applied.

H. Riser Isolators: Suspend risers from, or support risers by, spring hangers or spring isolators. Wherever possible, anchor risers at central point with resilient anchors. Provide hanger or mounting deflection of 0.75" except in those expansion locations where additional deflection is required to limit deflection or load changes to ±25% of initial deflection. Provide sliding guides held in position by resilient anchors, located between anchor points and end of piping, spaced as indicated.

I. Flexible Pipe Connectors:

1. For non-ferrous piping, provide bronze hose covered with bronze wire braid with copper tube ends or bronze flanged ends, braze- welded to hose.
2. For ferrous piping, provide stainless steel hose covered with stainless steel wire braid with NPT steel nipples or 150 psi ANSI flanges, welded to hose.

J. Flexible Pipe Connectors: Provide neoprene or EDPM construction consisting of multiple plies of nylon tire cord fabric and elastomer molded and cured in hydraulic rubber presses. Provide straight or elbow connector as indicated, rated at 125 psi at 220°F (104°C).

K. Acceptable Manufacturers:

1. Mason Industries, Inc.
2. Kinetics Noise Control, Inc.
3. M.W. Sausse & Co. Inc.
4. Amber/Booth, A VMC Company.

PART 3 - EXECUTION

3.01 INSPECTION

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

B. Manufacturer's Recommendations: Except as otherwise indicated, comply with manufacturer's recommendations for selection and application of vibration isolation materials and units.

3.02 APPLICATIONS

A. General: Except as otherwise indicated, select vibration control products in accordance with the latest edition of the ASHRAE Handbook, “Sound and Vibration Control". Where more than one type of product is offered, selection is Installer's option.

B. Piping: For piping connected to equipment mounted on vibration control products, install isolation hangers for first 3 points of support for pipe sizes 4" and less, for first 4 points of support for pipe sizes 5" through 8", and for first 6 points of support for pipe sizes 10" and over.

1. Earthquake Restraint: Where indicated or as required according to the contractor’s Seismic Restraint Plan, install earthquake-restrained spring isolator units and other assemblies required by the Plan.

3.03 INSTALLATION

A. General: Except as otherwise indicated, comply with manufacturer's instructions for installation and load application to vibration control materials and units. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.

B. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.

C. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

D. Locate isolation hangers as near overhead support structure as possible.

E. Flexible Pipe Connectors: Install on equipment side of shutoff valves, horizontally and parallel to equipment shafts wherever possible.

END OF SECTION 230548

SECTION 230553 - HVAC IDENTIFICATION

PART 1 - GENERAL

1.01 SUMMARY

A. Types of identification devices specified in this section include the following:

1. Plastic Pipe Markers.
2. Plastic Tape.
3. Valve Tags.
4. Valve Schedule Frames.
5. Engraved Plastic-Laminate Signs.
6. Plastic Tags.
7. Paint Stencils.

1.02 REFERENCES

A. American National Standards Institute (ANSI)

1. ANSI A13.1 “Scheme for Identification of Piping Systems”.
2. ANSI Z53.1 “Safety Color Code for Marking Physical Hazards”.

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

PART 2 - PRODUCTS

2.01 MECHANICAL IDENTIFICATION MATERIALS

A. General: Where more than single type is specified for application, selection is Installer’s option, but provide single selection for each product category.

2.02 PLASTIC PIPE MARKERS

A. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1.

B. Pressure-Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers, complying with ANSI A13.1.

C. Insulation: Furnish 1" thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125°F (52°C) or greater. Cut length to extend 2" beyond each end of plastic pipe marker.

D. Small Pipes: For external diameters less than 6" (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:

1. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
2. Adhesive lap joint in pipe marker overlap.
3. Laminated or bonded application of pipe marker to pipe (or insulation).
4. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4" wide; full circle at both ends of pipe marker, tape lapped 1-1/2".

E. Large Pipes: For external diameters of 6" and larger (including insulation if any), provide either full-band or strip-type pipe markers, but not narrower than 3 times letter height (and of required length), fastened by one of the following methods:

1. Laminated or bonded application of pipe marker to pipe (or insulation).
2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2" wide, full circle at both ends of pipe marker, tape lapped 3".
3. Strapped-to-pipe (or insulation) application of semi-rigid type, with manufacturer's standard stainless steel bands.

F. Lettering: Manufacturer's standard pre-printed nomenclature which best describes piping system in each instance, as selected by Architect/Engineer in cases of variance with name as shown or specified.

1. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.

2.03 PLASTIC TAPE

A. General: Provide manufacturer's standard color-coded pressure- sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.

B. Width: Provide 1-1/2" wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6". Provide 2 1/2" wide tape for larger pipes.

C. Color: Comply with ANSI A13.1, except where another color selection is indicated.

2.04 VALVE TAGS

A. Brass Valve Tags: Provide 19-gauge polished brass valve tags with stamp-engraved piping system abbreviation in 1/4" high letters and sequenced valve number 1/2" high, and with 5/32" hole for fastener.

1. Provide 1-1/2" diameter tags.

B. Plastic Laminate Valve Tags: Provide manufacturer's standard 3/32" thick engraved plastic laminate valve tags, with piping system abbreviation in 1/4" high letters and sequenced valve numbers 1/2" high, and with 5/32" hole for fastener.

1. Provide 1-1/2" sq. black tags with white lettering, except as otherwise indicated.

C. 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.

D. Access Panel Markers: Provide manufacturer's standard 1/16" thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve. Include 1/8" center hole to allow attachment.

2.05 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 SSB-grade sheet glass.

2.06 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 OR red** with white core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.

B. Fasteners: Self-tapping stainless steel screws, except contact- type permanent adhesive where screws cannot or should not penetrate the substrate.

2.07 PLASTIC TAGS

A. General: Manufacturer's standard pre-printed or partially pre-printed accident-prevention tags, of plasticized card stock with matte finish suitable for writing, approximately 3-1/4" x 5-5/8", with brass grommets and wire fasteners, and with appropriate pre-printed wording including large-size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).

2.08 PAINT STENCILS

A. Of size and color per ANSI/ASME A13.1 using clean cut letters and oil base semi-gloss enamel paint.

B. Paint material shall comply with Section 099000-Painting.

C. Size of Legend and Letters for Stencils:

Insulation or Pipe Diameter	Length of Color Field	Size of Letters
3/4" to 1-1/4"	8"	1/2"
1-1/2" to 2"	8"	3/4"

Insulation or Pipe Diameter	Length of Color Field	Size of Letters
2-1/2” to 6”	12”	1-1/4”
8” to 10”	24”	2-1/2”
Over 10”	32”	3-1/2”
Ductwork and Equipment	N/A	2-1/2”

PART 3 - EXECUTION

3.01 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.

3.02 PIPING SYSTEM IDENTIFICATION

A. General: Install pipe markers of one of the following types on each system indicated to receive identification, and include arrows to show normal direction of flow.

1. Plastic pipe markers, with application system as indicated under "Materials" in this section. Install on pipe insulation segment where required for hot non-insulated pipes.

B. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.

1. Near each valve and control device.
2. Near each branch, excluding short take-offs for 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 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 50' along each piping run, except reduce spacing to 25' in congested areas of piping and equipment.
7. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

3.03 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 units. List each tagged valve in valve schedule for each piping system.

B. Mount valve schedule frames and schedules in boiler rooms where indicated or, if not otherwise indicated, where directed by Architect/Engineer.

1. Where more than one major machine room is shown for project, install mounted valved schedule in each major machine room, and repeat only main valves which are to be operated in conjunction with operations of more than single machine room.

3.04 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. When more than one HVAC unit is present, it shall be permanently identified as to the area or space served by the equipment. Provide signs for the following general categories of equipment and operational devices:

1. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
2. Meters, gauges, thermometers and similar units.
3. Fuel-burning units including boilers, furnaces, heaters and absorption units.
4. Pumps, compressors, chillers, condensers and similar motor-driven units.
5. Heat exchangers, coils, evaporators, cooling towers, heat recovery units and similar equipment.
6. Fans, blowers, primary balancing dampers and mixing boxes.
7. Packaged HVAC central-station, zone-type and rooftop units.
8. Tanks and pressure vessels.
9. Strainers, filters, humidifiers, water treatment systems and similar equipment.
10. VAV terminals.
11. Pool dehumidification units.
12. Condensing units.
13. Unit heaters.

B. Optional Sign Types: Where lettering larger than 1" height is needed for proper identification, because of distance from normal location of required identification, stenciled signs may be provided in lieu of engraved plastic, at Installer's option.

C. Lettering Size: Minimum 1" high lettering for name of unit.

D. 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.

E. Ceiling Labels:

1. Fire and Smoke Damper Identification: Access points, i.e. access doors, access panels, lay-in ceiling tile, etc., shall be permanently identified on the exterior of the access point using a ½ inch wide clear label with black lettering reading: “SMOKE DAMPER” or “FIRE DAMPER” or “FIRE/SMOKE DAMPER”.
2. Provide ceiling labels to locate VAV terminals, fan coil units, cabinet heaters, exhaust fans, control dampers and other mechanical equipment above T-bar type panel ceilings.

Locate in corner of panel closest to equipment using ½ inch wide clear label with black lettering.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.01 RELATED WORK

A. Extent of testing, adjusting, and balancing work required by this section is indicated 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, and recommending modifications to the work as required by the contract documents.

1. Fans.
2. Air-handling units.
3. Ductwork systems, including terminal units.
4. Pumps.
5. Condensers.
6. Coils.
7. Boilers.
8. Piping systems.
9. Cabinet heaters.
10. Unit heaters.
11. Rooftop units.
12. Domestic hot water recirculating pumps & system balancing valves shown on plumbing plans.
13. VAV terminals.

1.02 QUALITY ASSURANCE

A. Contractor's Qualifications: Firm with at least 5-years of successful testing, adjusting, and balancing experience on projects with testing and balancing requirements similar to those required for this project.

1.03 QUALIFICATIONS OF CONTRACTOR

A. The **Mechanical Contractor / General Contractor / Owner** shall procure the services of an **independent** testing and balancing agency specializing in the testing, adjusting and balancing of environmental systems to perform the above-mentioned work. Testing and balancing report shall be certified by a Registered Professional Engineer, or a NEBB or TABB Certified Balancing Supervisor who is registered and/or certified in the jurisdiction where the testing is being conducted. The Engineer, NEBB, or TABB Supervisor shall represent the balancing firm in progress meetings as required, and shall be available for interpreting all material found in the balance report. Any individual involved in actual testing and balancing shall be under the direct supervision of the Registered Professional Engineer or the NEBB or TABB certified supervisor.

B. Codes and Standards:

1. NEBB Compliance: Comply with NEBB's latest edition of "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" as applicable to mechanical air **and hydronic** distribution systems, and associated equipment and apparatus.
2. TABB Compliance: Comply with TABB's "Testing, Adjusting and Balancing Bureau Standards, Procedure and Specifications" as applicable to mechanical air **and hydronic** distribution systems, and associated equipment and apparatus.
3. AABC Compliance: Comply with the latest edition of AABC's Manual MN-1 "AABC National Standards", as applicable to mechanical air **and hydronic** distribution systems, and associated equipment and apparatus.

1.04 APPROVAL OF CONTRACTOR

A. Testing, Adjusting and Balancing (TAB) firms acceptable to do the work are:

1. Air-Right, Inc.
2. Complete Mechanical Balancing.
3. Checkpoint Balance, LLC.
4. Double T Balancing Company.
5. Griffith Engineering Service Co.
6. Jedi Balancing, Inc.
7. JPG Engineering.
8. TAB Services.

B. Any Testing, Adjusting and Balancing (TAB) firm **other than those listed above** desiring to offer their services for this work shall submit their qualifications to the Engineer, not less than seven (7) calendar days before the bid date. Their submittals shall include the name and Professional Engineer stamp of the engineer who will be supervising the testing and balancing. Copies of each Supervisor's certificate shall be included in the submittals. This submittal of qualifications will be reviewed by the Engineer. The Engineer will then approve or disapprove this TAB firm based on these qualifications.

1.05 SUBMITTALS

A. Submit certified test reports, signed by Test and Balance Supervisor who performed TAB work. In addition, have the report certified by the Professional Engineer who is familiar with the TAB work on this project.

B. Submit biographical data on Engineer who is to directly supervise testing, adjusting, and balancing work.

1.06 JOB CONDITIONS

A. Do not proceed with testing, adjusting, and balancing work until work has been completed and is operable. Ensure that there is no latent residual work still to be completed.

B. Do not proceed until work scheduled for testing, adjusting, and balancing is clean and free from debris, dirt, and discarded building materials.

C. Put all heating, ventilating and air conditioning systems and equipment into full operation and continue operation of same during each working day of testing and balancing. Preliminary TAB requirements shall be ascertained prior to the commencement of work through a review of available plans and specifications for the project. In addition, visual observations at the site during construction shall be made to determine the location of required balancing devices and that they are being installed properly for the need.

D. Before any air balance work is done, the following will be completed on each system:

1. Check for duct leakage.
2. Assure filters are installed.
3. See that filters are changed if they are dirty.
4. Check for correct fan rotation.
5. Check equipment vibration.
6. Check automatic dampers for proper operation.
7. Place all volume control dampers and outlets wide open at this time.

E. Before any hydronic balancing work is done, the system shall be checked for plugged strainers, correct pump rotation, correct control valve installation and operation, air locks, check system static pressure to assure system operation is below the limits of the system relief valves, proper flow meter and check valve installation. All throttling devices and control valves shall be open at this time.

1.07 INSPECTION OF THE CONTRACT DOCUMENTS

A. The Test and Balance contractor shall request from the Division 23 contractor a set of documents so that he can review his ability to balance the mechanical system. If any portion of the system cannot be balanced due to its configuration, a report shall be issued to the Division 23 contractor pointing out those areas where proper balancing will be impossible to achieve. This report shall be issued in time to make corrective actions prior to the purchase of materials.

B. The TAB contractor shall obtain and review all equipment submittals prior to initiating the air **or water** balance work. Where values on the submittals vary from the contract documents, clarification shall be obtained from the engineer.

PART 2 - PRODUCTS

2.01 PATCHING MATERIALS

A. Except as otherwise indicated, use the same products as used by the 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. At Tester's option, plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.

2.02 TEST INSTRUMENTS

A. Utilize test instruments and equipment for TAB work required, of type, precision, calibration and capacity as recommended in the following TAB standards:

1. NEBB's Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
2. TABB’s Standards, Procedures and Specifications.
3. AABC's Manual MN-1 "AABC National Standards".

PART 3 - EXECUTION

3.01 GENERAL

A. Examine installed work and conditions under which testing is to be done to ensure that work has been completed, cleaned, and is operable. Do not proceed with TAB work until unsatisfactory conditions have been corrected in manner acceptable to Tester.

B. Test, adjust and balance environmental systems and components, as indicated, in accordance with procedures outlined in applicable standards.

C. Test, adjust and balance system during summer season for air conditioning systems and during winter season for heating systems, including at least period of operation at outside conditions within 5°F wet bulb temperature of maximum summer design condition, and within 10°F 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.

D. Balance all flows to terminals within +10% to -5% of design flow quantities. Measure and record the data.

E. Systems may be tested in increments when approved by the Engineer.

F. When testing and balancing involve the building temperature control systems, coordinate with the temperature control subcontractor to achieve the desired results. All setpoints shall be documented and included with test report.

G. When deemed necessary by the mechanical consulting Engineer, the Test & Balance firm shall run temperature and/**or humidity** recordings and shall read any of the air **or water** report quantities in the presence of the engineer for verification purposes.

H. Permanently mark the settings of valves, dampers, and other adjustment devices so that adjustment can be restored if disturbed at any time.

I. The contractor shall report observations made on the job such as noisy systems and unusual equipment vibration.

3.02 AIR BALANCE

A. Balance all supply, return and exhaust systems with air quantities for each air device; air handling units including supply, return, mixed, and outside temperatures and fan data including CFM, static pressure, fan RPM, motor running and full load amperage before and after final balance. Air diffusion patterns shall be set to minimize objectional drafts and noise.

B. The supply, return and exhaust fan static pressure shall be set by the balancing firm and the control contractor if the systems have fan volume control dampers. The duct static shall be confirmed both through the instrumentation installed on the job and by the balancing contractor. Fan air flows shall be confirmed by duct pitot traverse. The system shall be tested in all operation modes (full return air, full outside air, modulated damper position, full cooling). Amperages shall be checked in all modes. The fan speed resulting in satisfactory system performance shall be determined at full design delivery. Inlet or outlet fan volume control dampers shall be in the wide open position and one path presenting the greatest resistance to flow shall be fully open and unobstructed.

C. Verify operation of each room thermostat/sensor serving VAV terminal units over full range of heating and cooling to ensure proper sequence of control of the VAV operator and reheat coil valve. Field verify minimum and maximum air quantities of all variable volume terminal units and record final settings.

D. Final adjustments shall include, but are not limited to, the following:

1. All Fans: Direct Drive

   a. RPM with speed taps. Set fan speed on tap which most closely approaches design CFM. Report tap setting on equipment data sheet as high, medium or low.
   b. RPM with speed control rheostat or EC motor potentiometer. Set output of fan at design CFM by adjusting the SCR or potentiometer. After adjustment, check fans ability to restart after powering down. Increase setting if required for proper starting. Mark setting on the adjustment device.
   c. RPM with speed control by EC motor 0-10VDC external signal. Set output of fan at design CFM by determining the external EC motor speed signal. After adjustment, check fans ability to restart after powering down. Increase setting if required for proper starting. Balanced EC motor speeds shall be documented in the test and balance report as the applicable voltage (VDC) signal along with the corresponding air flow rates.
   d. RPM with variable frequency drive. Set output of fan at design CFM by adjusting the fan speed at the VFD's integral controller, do not set speed above limits recommended by the equipment manufacturer. After adjustment, check fans ability to restart after powering down. Increase setting if required for proper starting. Balanced VFD speeds shall be documented in the test and balance report as the applicable frequency (Hz) along with the corresponding air flow rates.

2. Motor Starter

   a. Mechanical Contractor Furnished

3. Thermal Heaters

a. Magnetic and Manual Starters. Furnish and exchange thermals as required for proper motor protection.

E. All major equipment performance tests shall be verified after system has been balanced and proper airflow rates established.

F. Patch holes in insulation, ductwork, and housings, which have been cut or drilled for test purposes, in manner recommended by original Installer. Report all damage requiring repair to the Division 23 contractor.

3.03 HYDRONIC BALANCE

A. Start hydronic balance after piping system has been cleaned, including strainers, and controls are functioning as required under other sections of Division 23.

B. Where liquid flow balancing cannot be accomplished due to system deficiencies such as excessive or lack of pumping head, inadequately sized motors, pressure drops not determinable or similar problems, prepare a list of such deficiencies and the suggested system modifications and furnish to the Engineer in writing and prior to submission of test report for necessary action.

C. Hydronic Balance shall include, but not be limited to the following:

1. Inlet and outlet water temperatures of all air handling unit coils, unit heaters, and other heat release equipment, as well as the corresponding media flows.
2. Boiler inlet and leaving water temperatures, reset supply temperature (if applicable), gas flow rate and flue gas analysis.
3. All circulating pump flow rates, pressures, running amperage, and full load amperage at design flow and shut-off conditions.
4. The hydronic system shall be proportionally balanced being certain that the path to one terminal is fully open.
5. Total system flow shall be adjusted at the pump by restricting the discharge balancing valve. If the pump must be severely restricted the impeller may have to be trimmed. This decision will be the responsibility of the contractor, supplier, and the mechanical engineer.
6. Total system flow shall be adjusted at the pump by setting the maximum motor speed at the VFD's integral controller, do not set speed above limits recommended by the equipment manufacturer. Balanced VFD speeds shall be documented in the test and balance report as the applicable frequency (Hz) along with the corresponding flow rates.
7. Check expansion tanks for water level and tank pressure. Record pressure.
8. Check all air vents for operation. Completely eliminate air from water systems.
9. Set and adjust water flow in all piping branches and risers, and record flow.
10. Three-way control valve bypass loops shall be set with the bypass loop balancing valves to provide the bypass flow rate equal to the percentage of total coil flow as indicted on the applicable details. Balance of bypass shall be completed with the control valve fully closed to the coil and fully open to the by-pass.

3.04 MINIMUM OSA QUANTITY OF VAV ROOFTOP UNITS

A. The Test And Balance Contractor may be required to assist the Temperature Controls Contractor in establishing a minimum outdoor air quantity under all supply flow conditions.

B. Test And Balance Procedure:

1. The Temperature Controls Contractor shall drive the VAV boxes to the minimum position. After the fan operation has stabilized the supply fan flow shall be provided by the Temperature Controls Contractor and noted for the test and balance report. The outdoor damper shall be set to provide the proper airflow and that setting shall be noted in the test and balance report. The Temperature Controls Contractor shall drive the VAV boxes to the maximum position. After the fan operation has stabilized the supply fan flow shall be provided by the Temperature Controls Contractor and noted for the test and balance report. The outdoor damper shall be set to provide the proper airflow and that setting shall be noted in the test and balance report. All four of these readings shall be provided to the Temperature Controls Contractor.

Description	Type	Device	Comments
Maximum Airflow	Setpoint	Measurement	From Test and Balance
Minimum Airflow	Setpoint	Measurement	From Test and Balance
Damper Position at Maximum	Setpoint	Measurement	From Test and Balance
Damper Position at Minimum	Setpoint	Measurement	From Test and Balance
Economizer Minimum	Setpoint	Calculation	

3.05 DUCT STATIC PRESSURE SETPOINT BALANCE:

A. The test and balance contractor shall assist the temperature controls contractor in determining the duct static pressure setpoint on variable air volume multiple zone air handling units or rooftop units for use in a VAV control sequence.

B. Procedure for duct static pressure setpoint balance:

1. TCC to set all boxes downstream of the static pressure sensor to operate at maximum airflow setpoints.
2. TCC to set all boxes upstream of the static pressure sensor to full shut-off (zero flow).
3. TCC to manually lower fan speed slowly while observing VAV box airflow rates downstream of the static pressure sensor. Stop lowering speed when one or more VAV box airflow rates just drops 10% below maximum airflow rate setpoint.
4. Once flow condition in previous step is achieved, note the DDC system static pressure reading at the duct static pressure sensor. This reading becomes the static pressure setpoint. Minimum set point shall be 1.0” WC.
5. If there are multiple static pressure sensors, repeat steps above for each sensor.
6. Record static pressure setpoint in balance report for each VAV multiple zone unit.

3.06 HOT WATER DIFFERENTIAL PRESSURE SETPOINT BALANCE:

A. The test and balance contractor shall assist the temperature controls contractor in determining the differential pressure set point on the hot water piping systems for use in the pump control sequences.

B. Procedure for differential pressure setpoint balance (Each System):

1. TCC to set associated valves downstream of the differential pressure sensor to operate at the full open position.
2. TCC to set all associated valves upstream of the differential pressure sensor to fully closed (zero flow).
3. TCC to measure flow at the last heating device while manually lowering pump speed. Stop lowering speed when associated coil flow rate reaches the scheduled coil flow rate.
4. Once flow condition in previous step is achieved, note the DDC system differential pressure reading at the transmitter. This reading becomes the differential pressure setpoint. Minimum set point shall be 15 psi.
5. Record differential pressure setpoint in balance report for each piping system.

3.07 DOMESTIC HOT WATER RECIRCULATION

A. Balance hot water recirculation pumps and all system balancing valves shown on plumbing drawings.

3.08 REPORT OF WORK

A. Submit **six (6) bound copies or an electronic copy** (or as required in Division 01) of the final testing and balancing report at least 15 days prior to the Mechanical Contractor's request for final inspection. All data shall be recorded on applicable reporting forms. The report shall include all operating data as listed in sections above, a list of all equipment used in the testing and balancing work, and shall be signed by the supervising engineer and affixed with his certification seal. Final acceptance of this project will not take place until a satisfactory report is received.

B. The pitot tube traverse method for determining CFM shall be used and recorded wherever possible.

C. Hydronic systems with meters: The system shall be balanced proportionally using the flow meters. On completion of the balance, the following information shall be recorded in the report: flow meter size and brand, required flow rate and pressure drop, valve settings on meters with a readable scale, flow rate in both full coil flow and full bypass modes.

D. Hydronic systems without meters (thermal or terminal rated pressure drop balance): the system shall be balanced proportionally to the terminal ratings. On completion of the balance the following information shall be recorded in the report: design entering and leaving water temperature/pressure drop, final balance entering and leaving water temperature/pressure drop.

E. When all hydronic balancing is done, all balancing valves shall be marked or the locking rings set.

F. After all balancing is complete and all coordination with the contractor and the engineer is complete, furnish a bound report which shall contain the following information:

1. RPM, drive sheave information (as installed and as changed), fan nameplate information, motor nameplate information, and amperage and voltage to all motors (in all operating modes).
2. Static pressure across all components of the system.
3. Original design and final balanced CFM at each system terminal. Include the terminal size, reading orifice size, and velocities read to attain the CFM.
4. Pump and motor nameplate information, amperage and voltage to all motors, pressure drop across all system terminals, pressure rise across the pump in PSI and feet of head.
5. Thermal protection for all motors shall be recorded. Starter brand, model, enclosure type, installed thermal heaters and the rating of the heaters, required thermal heaters and the rating of the heaters if different than installed shall be recorded. If the starters were furnished by the mechanical contractor, the heaters shall be changed to the correct size and so noted in the report. If the starters were furnished by the electrical contractor, the correct heater sizes shall be noted in the report and the electrical contractor shall be advised.
6. The report shall include a sheet which shall report the method of balance, project altitude, and any correction factors used in the calculations.
7. A reduced set of contract drawings shall be included in the report with all terminals (VAV boxes, outlets, inlets, coils, unit heaters, fintube loops, radiant panel loops, etc.) clearly marked and all equipment designated. Indicate all duct pitot traverse locations by a number which shall match identification numbers utilized in balance report.

3.09 GUARANTEE OF WORK

A. Guarantee the tests and balance for a period of 90 days from date of final acceptance of the test and balance report. During this period, the TAB Contractor shall make personnel available at no cost to the Owner to correct deficiencies in the balance or to help troubleshoot problem areas.

3.10 ADDITIONAL INSTRUCTIONS

A. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings at completion of TAB work. Provide markings with paint or other suitable permanent identification materials.

B. 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.

C. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.11 RETAINAGE

A. Contract payment retainage will be withheld against the Mechanical Contractor until the final completion of this section of work has been demonstrated by the submission of the TAB report and an evaluation of its contents has been made by the Engineer.

END OF SECTION 230593

SECTION 230700 – HVAC INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Refer to Section 23 3000: Air Distribution for lined ductwork requirements.

1.02 DESCRIPTION OF WORK

A. Types of mechanical insulation specified in this section include the following:

1. Piping System Insulation:

a. Glass Wool / Fiberglass.
b. Flexible Elastomeric.

2. Ductwork System Insulation:

a. Rigid and Flexible Glass Wool / Fiberglass.

3. Equipment Insulation:

a. Rigid Glass Wool / Fiberglass.
b. Calcium Silicate.
c. Flexible Elastomeric.
d. High Temperature Glass Wool / Fiberglass.

1.03 QUALITY ASSURANCE

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

B. Surface-Burning Characteristics: For insulation and related materials UL/ULC Classified per UL 723 or meeting ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
3. Glass Wool / Fiberglass

1.04 SUBMITTALS

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

B. Provide the following submittals:

1. Piping Insulation.
2. Pipe Fittings Insulation.
3. Ductwork Insulation.
4. Insulation Jackets.
5. Equipment Insulation.
6. Grease Duct / Ventilation Duct insulation.
7. Removable Insulation Covers.
8. Sealants.
9. Adhesives.
10. Mastics.
11. Field Applied Jackets.
12. Removable Insulation Covers.

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS

A. General:

1. Products shall not contain asbestos, lead, mercury, or mercury compounds.
2. Insulation materials applied to carbon steel shall be Mass Load Corrosion Rate (MLCR) tested per ASTM 1617.
3. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
4. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
5. All insulation materials installed within a plenum shall meet a flame spread rating of 25 and a smoke developed rating of 50 when tested per ASTM E84.

B. Piping Insulation:

1. Flexible Elastomeric Insulation:

a. Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1) Factory Applied Jacket:

a) None.

2) Field Applied Jacket:

a) See requirements below.

b. Acceptable Manufacturers:

1) Aeroflex: Aerocell
2) Armacell: Armaflex AP
3) K-Flex: Insultube

2. Glass Wool / Fiberglass, Preformed Pipe Insulation:

a. Type I, 850° F minimum. Materials: Glass Wool / Fiberglass bonded with a thermosetting resin. Comply with ASTM C 585, ASTM C 411, and ASTM C 547, Type I.

1) Factory Applied Jacket:

a) ASJ-SSL – comply with ASTM C1136, Type I.

2) Field Applied Jacket:

a) See requirements below.

b. Acceptable Manufacturers:

1) Johns Manville: Micro-Lok HP
2) Knauf Insulation: Earthwool 1000°
3) Owens Corning: Fiberglas Pipe Insulation

C. Ductwork Insulation:

1. Flexible Glass Wool / Fiberglass (Blanket) Insulation:

a. Glass Wool / Fiberglass bonded with a thermosetting resin. Comply with ASTM C 553, Type II; and ASTM C 1290, Type I, II, or III. Provide **0.75 pcf** density.

1) Factory Applied Jacket:

a) FSK – comply with ASTM C1136, Type II.
b) PSK – comply with ASTM C1136, Type II. Permeance of 0.02 perms or less per ASTM E96.

2) Field Applied Jacket:

a) See requirements below.

b. Acceptable Manufacturers:

1) Johns Manville: Microlite.
2) Knauf Insulation: Atmosphere Duct Wrap.
3) Owens Corning: SOFTR Duct Wrap.
4) CertainTeed: SoftTouch Duct Wrap.

2. Rigid Glass Wool / Fiberglass (Board) Insulation:

a. Glass Wool / Fiberglass bonded with a thermosetting resin. Comply with ASTM C 612, Type IA and IB; and NFPA 90A and 90B. Provide **3.0 pcf** density.

1) Factory Applied Jackets:

a) ASJ or AP – comply with ASTM C1136, Type I.
b) FSK – comply with ASTM C1136, Type II.

2) Field Applied Jacket:

a) See requirements below.

b. Acceptable Manufacturers:

1) Johns Manville: 800 Series Spin-Glas.
2) Knauf Insulation: Earthwool Insulation Board.
3) Owens Corning: Fiberglas Insulation Board.
4) CertainTeed: CertaPro Commercial Board.

D. Equipment Insulation:

1. Calcium Silicate Equipment Insulation:

a. ASTM C 533, Type I, Block or Type III, Special Shapes.

2. Flexible Elastomeric Equipment Insulation:

a. ASTM C 534, Type II.

3. Glass Wool / Fiberglass, Preformed Tank and Pipe Insulation:

a. Type I, 850° F minimum. Materials: Glass Wool / Fiberglass bonded with a thermosetting resin. Comply with ASTM C 585, ASTM C 411, and ASTM C 547, Type I.

1) Factory Applied Jacket:

a) ASJ-SSL – comply with ASTM C1136, Type I.

2) Field Applied Jacket:

a) See requirements below.

b. Acceptable Manufacturers:

1) Johns Manville: Micro-Lok HP
2) Knauf Insulation: Earthwool 1000°
3) Owens Corning: Fiberglas Pipe Insulation

4. Flexible Glass Wool / Fiberglass (Blanket) Insulation:

a. Glass Wool / Fiberglass bonded with a thermosetting resin. Comply with ASTM C 553, Type II; and ASTM C 1290, Type I, II, or III. Provide **0.75 pcf** density.
   1) Factory Applied Jacket:
      a) FSK – comply with ASTM C1136, Type II.
      b) PSK – comply with ASTM C1136, Type II. Permeance of 0.02 perms or less per ASTM E96.
   2) Field Applied Jacket:
      a) See requirements below.

b. Acceptable Manufacturers:
   1) Johns Manville: Microlite.
   2) Knauf Insulation: Atmosphere Duct Wrap.
   3) Owens Corning: SOFTR Duct Wrap.
   4) CertainTeed: SoftTouch Duct Wrap.

5. Rigid Glass Wool / Fiberglass (Board) Insulation:

a. Glass Wool / Fiberglass bonded with a thermosetting resin. Comply with ASTM C 612, Type IA and IB; and NFPA 90A and 90B. Provide **3.0 pcf** density.
   1) Factory Applied Jackets:
      a) ASJ or AP – comply with ASTM C1136, Type I.
      b) FSK – comply with ASTM C1136, Type II.
   2) Field Applied Jacket:
      a) See requirements below.

b. Acceptable Manufacturers:
   1) Johns Manville: 800 Series Spin-Glas.
   2) Knauf Insulation: Earthwool Insulation Board.
   3) Owens Corning: Fiberglas Insulation Board.
   4) CertainTeed: CertaPro Commercial Board.

6. Semi-rigid Glass Wool / Fiberglass (Pipe and Tank) Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100°F is 0.29 Btu in./h x sq. ft. x °F or less.
   1) Factory Applied Jackets:
      a) ASJ – comply with ASTM C1136, Type I.

7. High-Temperature, Flexible Glass Wool / Fiberglass (Blanket) Insulation:

a. Glass Wool / Fiberglass bonded. Comply with ASTM C 553, Type V, flexible, non-combustible meeting ASTM C 447, without factory-applied jacket.

8. High-Temperature, Rigid Glass Wool / Fiberglass (Board) Insulation:

a. Glass Wool / Fiberglass bonded. Comply with ASTM C 612, Type IA, IB, II - Category I, or III, without factory-applied jacket.

9. Equipment Insulation Compounds:

a. Provide adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.

10. Equipment Insulation Accessories:

a. Provide staples, bands, wire, wire netting, tape, corner angles, anchors and stud pins as recommended by insulation manufacturer for applications indicated.

E. Acceptable Manufacturers:

1. Industrial Insulation Group (IIG) (Calcium Silicate).
2. Aeroflex USA, Inc. (Elastomeric).
3. Armacell LLC (Elastomeric).
4. K-Flex USA (Elastomeric).
5. CertainTeed Corp.
6. Johns Manville.
7. Knauf.
8. Owens Corning.

2.02 ADHESIVES

A. General:

1. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Calcium Silicate Adhesive:

1. Fibrous, sodium-silicate-based adhesive with a service temperature range of 50° F to 800° F.

C. Flexible Elastomeric Adhesive:

1. Comply with MIL-A-24179A, Type II, Class I.

D. ASJ and FSK Jacket Adhesive:

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

E. PVC Jacket Adhesive:

1. Compatible with PVC jacket.

2.03 MASTICS

A. General:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic:

1. Water based; suitable for indoor use on below-ambient services.
2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.04 at 40-mil dry film thickness.
3. Service Temperature Range: Minus 20° F to plus 180° F.
4. Solids Content: ASTM D 1644, 52 percent by volume and 62 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic:

1. Solvent based; suitable for outdoor use on below-ambient services.
2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50° F to plus 220° F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

2.04 SEALANTS

A. General

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Joint Sealants for Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40° F to plus 250° F.
4. Color: Aluminum.

C. ASJ Flashing Sealants, and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40° F to plus 250° F.
4. Color: White.

2.05 FIELD-APPLIED JACKETS

A. General:

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

B. FSK Jacket:

1. Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. ASJ:

1. All Service Jacket. Kraft paper face, fiberglass-reinforced scrim, with aluminum backing.

D. PVC Jacket:

1. High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; 30 mils or less thickness; roll stock ready for shop or field cutting and forming.
2. Color: **White or (Color)** as selected by Architect.
3. Factory-fabricated fitting covers to match jacket.
4. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, traps, and mechanical joints
5. Acceptable Manufacturers:

    a. Johns Manville.
    b. Knauf.
    c. P.I.C. Plastics, Inc.
    d. Proto Corporation.
    e. Speedline Corporation.

E. Metal Jacket:

1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

    a. Sheet and roll stock ready for shop or field sizing or factory cut and rolled to size.
    b. 0.016” thick **smooth / embossed** finish.
    c. Moisture Barrier for Indoor Applications: 1-mil thick, heat-bonded polyethylene and kraft paper.
    d. Moisture Barrier for Outdoor Applications: 2.5 mil thick polysurlyn.
    e. Factory-Fabricated Fitting Covers:

        1) Same material, finish, and thickness as jacket.
        2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
        3) Tee covers.
        4) Flange and union covers.
        5) End caps.
        6) Beveled collars.
        7) Valve covers.

8) Field fabricate duct fitting covers only if factory-fabricated fitting covers are not available.

2. Acceptable Manufacturers:

a. Ideal Products.
b. ITW Insulation Systems.
c. RPR Products, Inc.

F. Self-Adhesive Aluminum Outdoor Jacket:

1. 60-mil thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with stucco-embossed aluminum-foil facing.
2. Acceptable Manufacturers:

a. Polyguard Products, Inc.
b. Venture Tape.

2.06 GREASE DUCT AND VENTILATION DUCT FIRE PROTECTIVE INSULATION WRAP

A. Fire Wrap Insulation: Provide high temperature fibrous thermal insulation blanket encapsulated in a fiberglass-reinforced polyester foil. Duct wrap density shall be nominal 6 pcf and have a nominal 1-1/2" thickness. The fiber blanket shall have a continuous use limit of 1000°C (1832°F). Blanket wrap shall comply with all applicable requirements of NFPA 96, local building codes and authority having jurisdiction.

B. Design Listings:

1. ASTM E 2336 and ICC-ES AC101 for grease duct enclosure.
2. ISO 6944 for ventilation duct – 1 and 2 hour fire resistive ratings.
3. ASTM E84 for a flame/smoke rating less than 25/50.

C. Fire Wrap Accessories: Provide staples, bands, wires, tape, anchors, pins, corner angles, and similar accessories as recommended by insulation manufacturer for grease or ventilation ductwork applications as indicated.

D. Provide the manufacturers fire barrier water tight sealant to firestop opening and penetrations in fire rated floor slabs, walls or other building partitions and assemblies. The sealant shall be a silicone elastomer that controls the spread of fire, smoke and noxious gasses.

E. Acceptable Manufacturers:

1. 3M Fire Barrier Duct Wrap 615+.
2. Thermal Ceramics FireMaster FastWrap XL.
3. Approved Equal (Submit prior approval to engineer prior to bid).

2.07 REMOVABLE INSULATION COVERS

A. General: Provide prefabricated, removable insulation jackets or removable insulation blocks for the following hydronic equipment. Jackets and blankets are individually fitted to each component.

1. Flanges
2. Isolation valves (butterfly, ball, gate)
3. Control Valves, Balancing Valves, Check Valves
4. Strainers
5. Suction Diffusers
6. Flexible pipe connections

B. Construction:

1. Jacket: silicone impregnated fiberglass fabric, rated for 500° F., meets Mil-C-20079G, UL-91 flame out 1 second, UL 723 flame spread 0, smoke development index 10, ASTM E84, IBC 42-1, NFPA 255, 17.5 oz/SY, 0.018" thickness, 60" width and 500 psi tensile strength..
2. Insulation: fiberglass, composed of 100% select grade type E glass fibers needled together to mat form, non-combustible, asbestos free with no resinous or inorganic binders. Conforms to Mil-I-24244, UL listed flame spread - 0, smoke - 0, 1200º F max temp, 60" width, K=0.40 at 300F, 0.50 at 500 F, 0.65 at 700º F.

   a. ½” thick, 6 oz/ft.^{2}, 9 lbs/cu.ft.
   b. 1” thick, 15 oz/ft.^{2}, 11 lbs/cu.ft.

3. Fastening: 2” Velcro, 1” straps and stainless steel D-rings, or 3/16” braided Kevlar drawstrings.
4. Color: silver or gray.

C. Acceptable Manufacturers:

1. Advanced Thermal Corp.
2. Fit Tight Covers.
3. Prior approved equal.

PART 3 - EXECUTION

3.01 GENERAL

A. Inspection: Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

B. Insulation Thickness: Pipe insulation minimum thickness shall be in accordance with the latest edition of the International Energy Conservation Codes and ASHRAE 90.1.

C. R Values: Insulation R values shall be in accordance with the latest edition of the International Energy Conservation Codes and ASHRAE 90.1.

3.02 HVAC PIPING SYSTEM INSULATION

A. General: Insulate HVAC piping per the following table:

HVAC PIPING INSULATION SCHEDULE					
System	**Location**	**Type**	**Pipe Size**	**Thickness**	**Jacket**
40°F-60°F Air Conditioner Condensate Drain Piping	Interior	Glass Wool / Fiberglass	All	1”	Factory ASJ-SSL Vapor Barrier
	Exterior	Glass Wool / Fiberglass	All	2"	Field Outdoor Aluminum
40°F-60°F Refrigerant Suction Piping Refrigerant Hot Gas Piping	Interior	Elastomeric	All	1"	None
	Exterior	Elastomeric	All	2"	Field Outdoor Aluminum
105°F-140°F Heating Water Piping	Interior	Glass Wool / Fiberglass	≤ 1-1/4”	1"	Factory ASJ-SSL
			1-1/2” and up	1-1/2”	
	Exterior	Glass Wool / Fiberglass	≤ 1-1/4”	2"	Field Outdoor Aluminum
			1-1/2” and up	2-1/2”	
141°F-200°F Heating Water Piping	Interior	Glass Wool / Fiberglass	≤ 1-1/4”	1-1/2"	Factory ASJ-SSL
			1-1/2” and up	2”	
	Exterior	Glass Wool / Fiberglass	≤ 1-1/4”	2-1/2"	Field Outdoor Aluminum
			1-1/2” and up	3”	
Pipe Fitting Covers	Interior	PVC Covers	All	Match system	Factory PVC
	Exterior / Tunnels	Aluminum Covers			Factory Aluminum

Notes:

- Interior location is inside of building thermal envelope.
- Exterior location is outside of building thermal envelope (i.e. rooftop or grade mounted piping).
- Refer to Equipment Insulation for valves and specialties.

B. Insulation Omitted:

1. Omit insulation on cold piping within unit cabinets provided piping is located over drain pan.
2. Omit insulation on hot piping within radiation enclosures or unit cabinets.
3. Omit insulation on factory installed piping with-in HVAC equipment tested and rated in accordance with an acceptable test procedure

C. The insulation thickness of piping smaller than 1-1/2” installed within a building partition wall, within a conditioned space, can be reduced by 1”; however total thickness shall not be less than 1”.

D. Encase pipe fitting insulation with flame and smoke rated one-piece premolded PVC fitting covers, fastened as per manufacturer's recommendations.

3.03 DUCTWORK SYSTEM INSULATION

A. General: Insulate HVAC ductwork per the following table:

HVAC DUCTWORK INSULATION SCHEDULE					
System	**Location**	**Type**	**Thickness**	**Jacket**	**R-Value**
Rectangular and Round Supply, Return, Transfer Air Duct	Interior Concealed	Flexible Glass Wool / Fiberglass	1-1/2"	Factory FSK	R-4.2
	Interior Exposed - Occupant Use Space	None	-	-	-
	Interior Exposed - Storage, Electrical, IT, Maintenance	Flexible Glass Wool / Fiberglass	1-1/2"	Factory FSK	R-4.2
	Fan / Machine Rooms	Rigid Glass Wool / Fiberglass	1-1/2"	Factory ASJ	R-6.5
	Exterior	Rigid Glass Wool / Fiberglass	3"	Field Outdoor Aluminum	R-13.0
	Unconditioned Spaces (attic, crawlspace)	Rigid Glass Wool / Fiberglass	2"	Factory FSK	R-8.7
Outdoor Air Duct and Combustion Air Duct	Interior Concealed	Flexible Glass Wool / Fiberglass	2"	Factory FSK vapor barrier	R-5.6
	Interior Exposed	Rigid Glass Wool / Fiberglass	1-1/2"	Factory ASJ vapor barrier	R-6.5
Exhaust Air Duct	Unconditioned Spaces (attic, crawlspace)	Flexible Glass Wool / Fiberglass	1"	Factory FSK	R-2.8
Supply, Return and Exhaust Duct for Natatorium	Interior Concealed	Flexible Glass Wool / Fiberglass	1-1/2"	Factory FSK	R-4.2
	Interior, Exposed in Natatorium	None	N/A	N/A	None
	Exterior	Rigid Glass Wool / Fiberglass	3"	Field Outdoor Aluminum	R-13.0
Notes: • Interior location is inside of building thermal envelope. • Exterior location is outside of building thermal envelope (i.e. rooftop or grade mounted ductwork).					

B. Insulation Omitted:

1. Omit external insulation on return air ductwork in return air plenums.

HVAC DUCTWORK LINER AND INSULATION SCHEDULE					
System	**Location**	**Type**	**Thickness**	**Jacket**	**R-Value**
Rectangular Supply, Return, Transfer Air Duct	Interior - all	Fiberglass Liner	1"	N/A	R-4.2
Spiral Round Supply, Return, Transfer Air Duct	Interior – Exposed	Fiberglass Liner	1"	N/A	R-4.2
Round Supply, Return, Transfer Air Duct	Interior – Concealed	Flexible Glass Wool / Fiberglass	1-1/2"	Factory FSK	R-4.2
Rectangular and Round Supply, Return, Transfer Air Duct	Exterior	Fiberglass Liner AND	1"	N/A	R-4.2
		Rigid Glass Wool / Fiberglass	2"	Field Outdoor Aluminum	R-8.7
	Unconditioned Spaces (attic, crawlspace)	Fiberglass Liner AND	1"	N/A	R-4.2
		Flexible Glass Wool / Fiberglass	1"	Factory FSK	R-2.8
Outdoor Air Duct and Combustion Air Duct	Interior Concealed	Flexible Glass Wool / Fiberglass	2"	Factory FSK vapor barrier	R-5.6
	Interior Exposed	Rigid Glass Wool / Fiberglass	1-1/2"	Factory ASJ vapor barrier	R-6.5
Exhaust Air Duct	Unconditioned Spaces (attic, crawlspace)	Flexible Glass Wool / Fiberglass	1"	Factory FSK	R-2.8

Notes:

- Interior location is inside of building thermal envelope.
- Exterior location is outside of building thermal envelope (i.e. rooftop or grade mounted ductwork).
- Refer to Section 23 3000 for fiberglass duct liner requirements.

C. Insulation Omitted:

1. Do not insulate lined ductwork unless specified above.
2. Omit external insulation on return air ductwork in return air plenums.

3.04 GREASE DUCT AND VENTILATION DUCT FIRE PROTECTIVE INSULATION WRAP INSTALLATION

A. Grease Ductwork Systems:

1. Application Requirements: Insulate all grease ductwork system with fire protective insulation wrap.
2. Insulate each grease ductwork system specified above with the following type and thickness of insulation:

   a. Grease Duct Fire Protective Insulation Wrap.

1) 2 layers of insulation in compliance with manufacturer's published instructions, UL listings, and shop drawings to meet installation requirements for Grease Duct per ASTM E 2336.

B. Ventilation Ductwork Systems:

1. Application Requirements: Insulate all ventilation ducts where indicated on the plans with fire protective insulation wrap.
2. Insulate each ventilation ductwork system specified above with the following type and thickness of insulation:

a. Ventilation Duct Fire Protective Insulation Wrap.

1) 1 layer of insulation in compliance with manufacturer's published instructions, UL listings, and shop drawings to meet installation requirements for Ventilation Duct per ISO 6944.

3.05 EQUIPMENT INSULATION

A. General: Insulate HVAC equipment per the following table:

HVAC EQUIPMENT INSULATION SCHEDULE				
System	**Location**	**Type**	**Thickness**	**Jacket**
Heating Water Equipment: Heating Water Pumps, Air Separators, Heat Exchangers, Valves and Piping Specialties	Interior – all	Rigid or Semirigid Glass Wool / Fiberglass OR	2"	Factory ASJ
		Calcium Silicate	3"	
		Calcium Silicate	5"	
Valves and piping specialties that require access for adjustment or maintenance	Mechanical Equipment Rooms, tunnels	Removable insulation Covers	1"	Factory

B. Application:

1. Provide removable sections or removable block for any access point. Refer to Installation Piping and Ductwork Insulation and Installation of Equipment Insulation sections for requirements.

C. Exceptions:

1. Do not insulate factory pre-insulated equipment.
2. Do not insulate factory pre-insulated or double wall flues.
3. Omit insulation on heating water strainers, control valves and balancing valves associated with piping 1" or less in diameter.

3.06 INSTALLATION OF PIPING AND 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.

B. Install insulation on pipe systems subsequent to installation of heat tracing, painting, 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 insulation, and protect to prevent puncture or other damage.

F. Insulation Installation on Valves and Pipe Specialties: Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Apply insulation as follows.

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.
5. Use removable jackets for insulation of valves and specialties where access is required for adjustment or maintenance. (IE pressure independent control valves)

G. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

H. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation.
2. Install with preformed pipe fitting covers as scheduled.

    a. Overlap at longitudinal seams and end joints, for horizontal applications.
    b. Seal with manufacturer’s adhesive. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge

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

J. Insulation should go through the hanger with the insert carefully placed in a notch in the insulation at the 6 o’clock position between the pipe and the shield. For hot pipes, apply 3"

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" wide vapor barrier tape or band.

K. Install insulation and vapor barrier jackets continuous over piping at trapeze hangers.

3.07 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.

B. 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.

C. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.

D. Do not apply insulation to equipment while hot.

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

F. 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.

G. Cover insulated surfaces with all-service jacketing neatly fitted and firmly secured. Lap seams at least 2". Apply over vapor barrier where applicable.

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

I. Gasketed Plate and Frame Heat Exchangers shall be insulated as per the schedule, fully insulate all plates and the plate covers on each end, cut and seal insulation penetrations by the carrying bar and guide bar. Provide 3” round smooth cut openings on each end of the tightening bolts and fill openings using removable 3” round closed cell elastomeric insulation.

J. 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.

K. Equipment Exposed to Weather: Protect outdoor insulation from weather by installation of weather-barrier mastic protective jacketing, as recommended by manufacturer.

3.08 EXISTING INSULATION REPAIR

A. Repair damaged sections of existing mechanical insulation, both previously damaged or damaged during this construction period. Use insulation of same thickness as existing insulation, install new jacket lapping and sealed over existing.

3.09 PROTECTION AND REPLACEMENT

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

B. Replace and repair insulation disturbed by testing and balancing procedures required under Section 23 0593.

C. 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

SECTION 230923 - TEMPERATURE CONTROL SYSTEMS - DDC

PART 1 - GENERAL

1.01 SUMMARY

A. Scope: This section contains general requirements for all work to be provided by the Temperature Controls Contractor.

B. Refer to Section 230500 – Common Work Results for HVAC, for electrical, mechanical and temperature control contractor coordination of responsibilities.

C. All communication wiring between DDC controllers, sensors and devices shall be hardwired as part of the complete system provided by the temperature controls contractor. Wireless controllers, sensors and devices shall not be permitted.

D. The temperature controls contractor shall be responsible for providing and verifying all control sequences described in this section or in the Sequence of Operations regardless of whether the sequence uses the building automation system, unitary controls or third-party control systems, or any combination of systems. Any deviation from the sequence of operations, including limitations caused by the lack of ability of the building automation system to interact with unitary or third-party controls shall be clearly and prominently described as a deviation in the temperature controls submittal. The temperature controls contractor shall be responsible for coordinating and assuring the sequence of operations will be compatible with all equipment, including equipment purchased by other contractors. The temperature controls contractor will be responsible for correcting any interface problems that prevent the system from operating according to the sequence of operations.

E. Work Included: It is the intent of this specification for the building automation system to be fully networked and installed as a complete package by the Temperature Controls Contractor. The system shall include all computer software and hardware, controllers, sensors, transmission equipment, system workstations, local panels, installation, engineering, supervision, acceptance test, training, warranty service and, at the owner's option, extended warranty service.

F. All controller hardware and software provided under this section shall be BACnet MS/TP compliant to provide the owner with an open, interoperable direct digital control system that will allow microprocessor control hardware and software from different control, fire alarm or card access system manufacturers to be integrated to this control system.

G. The system shall be capable of supporting an unlimited number of clients using a standard Web Browser such as Internet Explorer or Netscape Navigator.

H. Line Voltage: It is the intent of this specification for the temperature controls contractor to provide all wiring and conduit for the purpose of temperature controls, whether low voltage or line voltage (120vac or less). The temperature controls contractor shall coordinate with the Electrical Contractor to have the Electrical Contractor locate a junction box or boxes served by 120volt for the purpose of temperature controls. For devices that require line voltage (120vac or less) controls, the thermostat and wiring and conduit shall be the responsibility of the

temperature controls contractor. If additional circuits/breakers are required it shall be the responsibility of the electrical contractor to provide. ***The temperature controls contractor shall not exclude line voltage controls in their proposal.***

1.02 QUALIFICATIONS

A. The control system shall be furnished, engineered, and installed by the manufacturer's local factory authorized office. The control contractor shall have factory trained technicians to provide instruction, routine maintenance, and emergency service within 48 hours upon receipt of request.

B. Control system components shall be new and in conformance with the following applicable standards for products specified:

1. American Society for Testing and Materials, ASTM.
2. Institute of Electrical and Electronic Engineers, IEEE.
3. National Electrical Manufacturers Association, NEMA.
4. Underwriters Laboratory, UL (UL 916).
5. FCC Regulation, Part 15, Section 156.
6. National Fire Protection Association, NFPA.
7. Local Building Codes.

1.03 SUBMITTALS

A. General: Incomplete submittal packages will be returned un-reviewed. A partial submittal consisting of a damper and valve schedule will be accepted for projects with short construction schedules, provided a written request is submitted to the engineer. Submittal requirements are intended to eliminate or minimize engineering of either control hardware or software in the field, and shall be adhered to.

B. Sequences of Operation Submittals: The Controls Contractor’s submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:

1. An overview narrative of the system generally describing its purpose, components and function.
2. All interactions and interlocks with other systems.
3. Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
4. Written sequences of control for packaged controlled equipment.
5. Sequences of control for the following modes of operation: Start-up, Warm-up, Cool-down, Normal Occupied, Unoccupied, and Shutdown.
6. Capacity control sequences and equipment staging.
7. Temperature and pressure control: setbacks, setups, resets, etc.
8. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
9. Effects of power or equipment failure with all standby component functions.
10. Sequences for all alarms and emergency shut downs.

11. Seasonal operational differences and recommendations.

C. Drawings: The controls contractor shall submit AutoCAD (Version 2000 or higher) generated schematic drawings in hard copy and electronic media for the entire control system, for review and approval before work shall begin. The hard copy drawings shall be submitted on 8½" x 11" or 11" x 17" sheets with drawing information sized such that all drawing information is legible. The submittal drawings shall include the following:

1. A one-page diagram depicting the system architecture complete with a communications riser and peripheral devices.
2. Floor plan layouts including locations of controlled equipment, communication bus and/or network wiring layout, thermostat locations, and terminal unit controllers with communication address identifiers.
3. Mechanical room layouts including locations of controlled equipment, communication and network wiring layout, and panel locations with unit communication address identifiers.
4. Point-to-point wiring diagrams for each HVAC system accurately depicting:

    a. All temperature controls located on a schematic diagram of the controlled HVAC system.
    b. Start-stop arrangement for each piece of equipment.
    c. Equipment interlocks.
    d. Wiring terminal numbers.
    e. Special connection information required for properly controlling the mechanical equipment.
    f. Control enclosure interior and exterior (face) layouts.

5. A bill of material reference list with drawing tag identifiers, application description, manufacturer, model number, and quantity.
6. Sequences of operation which shall identify each major component (hardware and software) involved in the control scheme by its tag identifier.
7. Software flow diagrams for each sequence of operation. Provide detail of all parameters; of inputs, outputs, PID loops, and auxiliary control functions. This requirement applies to both text editing and function block programming types. DDC systems that utilize block programming shall submit the flow diagrams utilizing the actual object oriented blocks, with a key of block types and block descriptions.
8. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.

D. Technical Data: The submittal shall also include manufacturers catalog data describing each item of control equipment or component provided and installed for the project. Include and identify all data needed to show adherence to the corresponding specification section.

E. Damper Schedule: Provide a damper schedule with tag identifiers, application descriptions, damper sizes, damper arrangements, product type/name, actuator type, and actuator quantity for each damper. Include damper/actuator product cut sheets and identify all technical data needed to show adherence to the corresponding specification section.

F. Valve Schedule: Provide a valve schedule which describes valve tag identifiers, application descriptions, specified GPM's, close-off rating, valve Cv ratings, pressure drop at rated Cv, port

arrangement and actuator type for each valve. Include valve/actuator product cut sheets and identify all technical data needed to show adherence to the corresponding specification section.

G. Specification Compliance: Irrespective of any prior approval to bid, the submittals shall include a specification compliance analysis for review and approval before work shall begin. The compliance document shall address each paragraph of Part 1, Part 2, Part 3, and Part 4 of the specification by indicating COMPLY, or EXCEPTION. Do not indicate COMPLY unless the proposed system exactly meets the paragraph requirement. If EXCEPTION is indicated, then provide a clear and concise explanation of the variance from the specifications and the effect this has on the specified system performance. A schematic diagram showing the proposed system architecture and describing the expendability and capacity of the proposed system shall be included. The schematic shall have all non-applicable items clearly deleted and shall indicate the quantity of each component to be utilized to meet the requirements of this specification. The Engineer shall retain the right to accept or reject any listed exceptions to the specification.

H. Acceptance Test Plan:

1. Submit a detailed description of acceptance testing procedures that will be utilized to confirm proper operation of all sequences of operation and points, along with acceptance testing checkoff sheets.

I. Training Plan: Submit a detailed description of the training to be provided to Owner's personnel for the Engineer's approval. Plan shall include comprehensive details on: course outline, schedule, synopsis, training materials required/supplied and shall include the identity and credentials of the course instructor(s).

J. Correction Period Support Plan: Submit a detailed description of the plan to support the owner during the correction period. Provide comprehensive details for: standard workday emergency problem response methods, planned preventative maintenance schedules, training and other plan information for the Engineer's approval.

1.04 PROTECTION OF SOFTWARE RIGHTS

A. Prior to delivery of software the Owner and the party providing the software will enter into a software license agreement with provisions for the following:

1. Limiting use of software to equipment provided under these specifications.
2. Limiting copying.
3. Preserving confidentiality.
4. Prohibiting transfer to a third party.

1.05 WARRANTY

A. See Section 017800 – Closeout Submittals, for general warranty requirements.

B. Upgrades: Include all controller firmware and software updates for the installed system version at no additional cost to the system owner during the warranty period.

PART 2 - PRODUCTS

2.01 BIDDING REQUIREMENTS

A. Contractors wishing to bid temperature controls shall present a stand-alone temperature controls price.

B. The temperature controls price may be predicated on using a particular brand of mechanical equipment, but must be clearly stated.

C. An alternate price may be given in the event the desired brand of mechanical equipment is not used.

D. Acceptable manufacturers:

1. Johnson Controls installed by Local Factory Office.

2.02 SYSTEM ARCHITECTURE

A. The complete electronic DDC temperature control system shall be comprised of five levels of control. Provisions for expansion of all levels of the DDC system shall be provided with this project such that a need for future "gateway" or "repeater" expansion hardware and software is not required:

1. The First Level is comprised of electronic sensors, valves, dampers, actuators, switches, relays, and transducers, etc.
2. The Second Level includes dedicated zone controllers for VAV box, and FTU units.
3. The Third Level is comprised of local controllers for control of large primary mechanical systems such as air handling systems or heating water systems.
4. The Fourth Level consists of the system controller(s) which are used for high level global programming functions and system networking.
5. The Fifth Level is the System Workstation which includes the hardware and software necessary for an operator/engineer to interface with the control system.

B. DDC control system shall be fully wired, wireless controls, sensors or devices are not acceptable.

2.03 SENSOR/TRANSMITTERS

A. Network Sensors: Sensors shall be linear precision elements with temperature and humidity ranges appropriate for the application. Accuracy for temperature sensing within 1°F over the entire span: and accuracy for humidity sensing within 1% RH over the entire span:

1. DDC zone network sensors shall be used for detection and control of zone temperature and zone humidity (where indicated) in each individual control zone. Where humidity sensing is not indicated provide temperature only network sensors.

a. Network sensors in administration office applications shall be provided with zone temperature indication via a digital display and shall have a warmer/cooler adjustment. The warmer/cooler adjustment shall be software limited to +/- 2°F.
b. Network sensors in all public areas shall be provided with a warmer/cooler adjustment. Sensors shall have blank covers with no display and the warmer/cooler adjustment shall be software limited to +/- 2°F.
c. Network sensors shall be provided with an occupied/unoccupied override pushbutton in administration areas and elsewhere where indicated.

2. Network sensors shall be wired using the manufacturers standard communication cabling. Wireless sensors are not acceptable.

B. Duct mounted averaging sensors shall utilize a sensing element incorporated in a copper capillary with a minimum length of 20 feet. The sensor shall be looped across the coil, installed per the manufacturer's recommendation and fastened at a minimum of every 36 inches. Loops shall extend the full width of the coil and shall be spaced vertically no greater than 24". On large coils provide multiple averaging sensors as require for complete coverage of the coil.

C. Sunshields shall be provided for outside air sensors.

D. Thermowells for all immersion sensors shall be stainless steel or brass as required for application.

E. The following are typical sensor application ranges:

1. Space: 20°F - 100°F
2. Heating Water: 50°F - 250°F
3. Outside Air: -40°F - 140°F
4. Mixed Air: 20°F - 100°F

F. Differential Pressure Sensor: Differential pressure sensor shall be temperature compensated and shall vary the output voltage with a change in differential pressure. Sensing range shall be suitable for the application with accuracy of +/- 2% of range and repeatability of +/- 0.5% of range. Sensor shall be capable of withstanding up to 150% of rated pressure for air applications **and 300% of rated pressure for water applications without damage**.

G. Humidity Sensors: Humidity sensors shall be of the solid-state type using a hygroscopic polymer sensing element. The sensor shall vary the output voltage with a change in relative humidity. Sensors shall be available for room or duct mounting, with a minimum range of 30% - 80% ± 5%.

H. Air Velocity Sensors: Sensor shall use thermal anemometry to determine air flow rate. Repeatability shall be ± 25 FPM; accuracy ± 5% of range. The anemometer shall use constant temperature differential technology and operate from 30°F to 120°F.

I. Carbon Dioxide Sensor:

1. Sensor shall be self-calibrating. Sensor shall be designed to monitor CO2 levels, in accordance with ASHRAE Standard 62-2001, have a 4-20 mA output, have an accuracy at 20°C < (40ppm +/- 3% of reading), and a range of 0-2000 PPM, adjustable to 20,000 PPM.

a. Duct Mounted type: Viasala GMD20 or approved equal.
b. Wall mounted type: Viasala GMW80, or approved equal.

J. Occupancy Sensor: Occupancy sensor shall be of the passive infrared or ultrasonic receiver type. As a minimum the occupancy sensor shall provide adjustments for timed-on delay and sensor sensitivity.

K. Provide all wall mounted sensors including network sensors, thermostats, humidistats, and CO2 sensors in unsupervised public spaces with **cast guard or plastic cover or wire cage** type protective covers. Guards shall be key lockable and rigidly secured to wall using tamper resistant hardware and base. Spaces requiring guards include but are not limited to corridors, gymnasiums, cafeteria, stage, entry lobbies and entry vestibules.

2.04 AUXILIARY ELECTRIC CONTROL DEVICES

A. Control Relays: Shall be UL listed plug-in type with dust cover, LED "energized" indicator and integral H-O-A switch. Contract rating, configuration and coil voltage shall be suitable for the application.

B. Manual Control Switches: Shall be UL listed for use in NEMA 1 enclosures with contact arrangement and rating suitable for the application. Bat handle or knob actuator with nameplate clearly identifying function of each switch position.

C. Line Voltage Thermostats: Line Voltage Thermostats shall be U.L. listed with SPDT contacts, switching at an adjustable setpoint with a range of 55° to 85°F. Provide lockable guards for all thermostats located in areas where mechanical damage or tampering may occur.

D. Differential Pressure Switches: Pressure differential switches (air **or water** service) shall be UL listed, DPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as specified. Switches shall be capable of withstanding up to 150% of rated pressure for air applications **and up to 300% of rated pressure for water applications**. Duct high pressure switches shall be provided with contacts that require manual resetting.

E. Current Sensing Relays: Current Sensing Relays shall be U.L. listed and of the proper range. The switch output contact shall be rated for 30VDC. Threshold setting shall be fully adjustable within the selected range. Response time shall be 0.25 seconds or less. Provide current sensing relays on all fans and pumps for status sensing unless otherwise noted.

F. Low Temperature Thermostats: Low Temperature Thermostats shall be U.L. listed, DPDT snap-acting, pilot duty rated (125 VA, minimum), NEMA 1 enclosure with manually adjustable set point and differential suitable for the application or as specified. Switches shall be actuated by the coldest 1' of a 20' capillary and shall be provided with contacts that require manual resetting. The element shall be properly supported to cover the entire downstream side of the heating coil with a minimum of three loops. Separate thermostats shall be provided for each 25 square feet of coil face area or fraction thereof. The setpoint shall be 25°F unless otherwise specified on the plans or sequence of operation.

G. Flow Switches: Flow Switches shall be U.L. listed and shall be of the paddle type equipped with DPDT contacts to establish proof of flow. Flow switches shall be of the vapor-proof type.

H. Control Transformers: Shall be UL listed Class 2 current-limiting type, or shall be furnished with over-current protection in both primary and secondary circuits for Class 2 service.

I. Damper End Switches: Shall be UL listed line voltage SPDT snap-acting pilot duty rated (125 VA minimum) NEMA 1 enclosure, with roller type actuating arm suitable for damper position application.

J. Push/pull Boiler Room/Chiller Room Emergency Stop Switch: Large, heavy duty push – pull to reset, 24V, with non-locking hinged cover to prevent accidental trip. Provide NEMA 1 enclosure for all indoor applications and weather tight NEMA 4X for all outdoor applications. Wall plate shall indicate "EMERGENCY BOILER SHUTDOWN" or "EMERGENCY CHILLER SHUTDOWN".

1. Pilla model BSD120 or equal.

K. Smoke Detectors: Shall be as specified in the schedule of responsibilities:

1. Smoke detectors located in air handling units or ducts shall be complete with duct-mounting accessories as recommended by manufacturer. Provide multiple units for larger duct areas consistent with manufacturer's recommendations.
2. Provide all control interlock wiring from fire/smoke alarm system relay contacts to HVAC controls unless this wiring is noted in the Division 26 plans or specifications

L. Outside Air Measuring Stations (Where not integral to the equipment)

1. Basis-of-Design Product: Provide Paragon Controls Inc.; MicroTrans EQ or equal.
2. Span: Factory calibrated to match the application.
3. Accuracy: 0.25% of full scale including non-linearity, hysteresis, deadband and non-repeatability.
4. Signal Conversion Resolution: 24-bit A/D and 12-bit D/A.
5. Temperature Effects: Less than 0.03 percent full scale per deg F (Less than 0.045 percent full scale per deg C).
6. Over-pressure: 15 psid proof, 25 psid burst.
7. Noise Filtration: Response time to reach 98 percent of a step change adjustable from 0 to 200 seconds in 1 second increments.
8. Output: 4-20 mA or 0-10 Vdc.
9. Enclosure: NEMA 1 rated flame-retardant ABS plastic.
10. Capable of twelve-point linearization and four-point flow correction.
11. Large backlit LCD for configuration and local indication of measured process.
12. Six button touch pad and password protected menus for field configuration of engineering units, process noise filtering, operating range, and alarm set points.
13. Automatic Zeroing Circuit: For operating velocities below 1,266 fpm, include an automatic zeroing circuit that is field configurable for frequency of activation between one and twenty-four hours on 1-hour intervals. Signal processor output shall be locked and maintained at last given output value during automatic zeroing period so as not to interrupt automatic control process. Meter shall be auto calibrated to accuracy of plus or minus 1 count.
14. Monitoring and configuration shall be performed through BACnet MS/TP communication network.

M. Water Flow Measuring (Insertion Type)

1. Basis-of Design Product (Single Direction Flow): Onicon Model F-1210 Dual Turbine Flow Meter
2. Basis-of Design Product (Two Direction Flow): Onicon Model FB-1210 Dual Turbine Flow Meter
3. Include all installation hardware necessary to enable insertion and removal of the meter without system shutdown.
4. The flow meter shall be hand-insertable up to 400 psi.
5. The flow meter shall have dual contra-rotating axial turbines, with electronic impedance-based sensing and an averaging circuit. Wetted metal components shall be 316L SS.
6. The maximum operating temperature shall be 280 degrees F.
7. Each flow meter shall be individually wet-calibrated against a primary volumetric standard that is accurate to within 0.1% and traceable to the National Institute of Standards and Technology.
8. The manufacturer's certificate of calibration shall be provided with each flow meter. Accuracy shall be within ± 0.5% of rate at the calibrated velocity, within ± 1% of rate over a 10:1 turndown (3.0 to 30 ft/s) and within ± 2% of rate over a 50:1 turndown (from 0.4 to 20 ft/s).
9. The flow meter shall include integral analog output(s), 4-20 mA, 0-10V, or 0-5V.
10. Bi-directional meters shall include an isolated contact closure output for direction.
11. Provide an integral display module for local indication of flow rate.
12. Provide two direction type in any instance where flow is reversible.

2.05 CONTROL VALVES

A. General:

1. All valves to heating coils which are part of an air handling system which takes in outside air shall open for full supply water flow whenever a loss of power or air supply to the valves occurs. Chilled water valves shall fail closed.
2. Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

    a. Water Valves:

        1) Two-way - 125% of total system (pump) head.
        2) Three-way - 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

3. The temperature control contractor shall size control valves for proper control characteristics for each application. Control valves shall be sized for a pressure drop between 3 to 5 psig at full flow condition.
4. The valve trim shall consist of a removable cage providing valve plug guiding throughout the entire travel range. A stainless-steel stem shall be provided. Bonnet, cage, stem and plug assembly shall be removable for servicing.
5. All modulating valves shall have equal flow characteristics, i.e., for equal increments of valve stem stroke the change if flow rate with respect to valve stroke will be expressed as a constant percent of the flow rate at the time of the change.
6. All control valves over 3/4 inch shall have a minimum rangeability (the ratio of the maximum controllable flow to the minimum controllable flow) of 50 to 1.

7. All two position isolation valves shall be line size. Butterfly valves may be used for any isolation valve application.

B. Valve Characteristics:

1. Valves - 1/2" to 2": Valves shall be constructed with a cast iron bronze body and screwed ends. The body rating shall be a minimum of 250 psig.
2. Valves - 2½" and above: Valves shall be constructed with a cast iron body and have flanged connections. The body rating shall be a minimum of 125 psig.

C. Valve Actuators:

1. Valve actuators shall have a cast aluminum or cast-iron housing.
2. Actuators shall have sufficient power to operate the valve and provide for tight shut-off at the differential pressures encountered.
3. Provide spring return actuators for all applications unless noted otherwise.
4. Where required by the sequence of operation, valves shall be capable of being sequenced with other valves or other actuated devices. Where such sequencing is required, the actual spring range, when adjusted for spring shift, shall be such that no overlapping occurs. In the event that spring shift causes an overlap, a pilot positioner shall be furnished.
5. Electric actuators shall be oil-immersed gear train, rotary, hydraulic or magnetic type except as noted otherwise.
6. Electric actuators for VAV and reheat terminal unit applications may be three-point floating type for valves that are 3/4 inch or less. These actuators are not required to be spring-return.
7. Actuators providing control by temperature change media within the actuator are not acceptable.
8. Feedback: Where indicated, provide electronic valve actuators with ability to monitor position as a DDC system analog input on the actuator.

2.06 CONTROL DAMPERS

A. Motorized dampers, unless otherwise specified elsewhere, shall meet the following:

1. Frame of 16-gauge steel structural hat channel.
2. Blades of 14-gauge galvanized steel, roll-formed airfoil-type design with extruded vinyl blade edge seals mechanically locked into the blade edge.
3. Stainless-steel (28-gauge minimum) jamb seals of flexible, compression type.
4. Control shaft shall be 1/2" dia. removable shaft. Linkage shall be located outside of airstream.
5. Leakage shall be a maximum of 0.10% of maximum flow based on a pressure differential of 1.0" w.g.
6. Airfoil type dampers shall be used for any applications where the air velocities are greater than 1500 FPM.
7. Provide a minimum of one damper actuator per damper section.

B. Unless otherwise scheduled, the control dampers for outdoor/return air mixing box dampers shall be parallel blade, arranged to direct airstreams towards each other. Dampers used for air

volume or pressure control modulating applications shall be opposed blade type. All other dampers may be parallel or opposed blade type.

C. Damper Actuators:

1. Electric actuators shall be direct coupled typed.
2. Unless otherwise noted, all actuators must be spring return type. Under no circumstances shall capacitors or batteries be used in lieu of spring return.
3. Actuators for VAV terminal control may be non-spring return.
4. Feedback: Where indicated, provide motorized damper actuators with ability to monitor position as a DDC system analog input on the actuator.

2.07 LOCAL CONTROL PANELS

A. All relays, switches, transducers and other field interface devices, for equipment located within the mechanical equipment rooms, shall be panel mounted. Each local control panel shall have door mounted devices as shown on the drawings. Provide a convenience 120 VAC receptacle in each panel. All electrical devices, within the panels shall be wired to a numbered terminal strip. All wiring within the panel shall be run in wiring tray in accordance with NEMA and UL standards, and shall meet all local codes. Panels shall be NEMA type suitable for applications as required. Provide a final as-built control drawing, reduced, laminated, and mounted inside of the panel door. Provide panel with 20% spare mounting capacity.

2.08 MISCELLANEOUS

A. The Controls Contractor shall furnish all electric relays and coordinate with the supplier of magnetic starters for the auxiliary contact requirements. All electric control devices shall be of a type to meet current, voltage, and switching equipment of their particular application. Relays shall be provided with 24 VAC coils and contacts shall be rated at 10 amps minimum.

2.09 ZONE CONTROLLER HARDWARE

A. General: Each HVAC Zone Controller shall be a stand-alone DDC controller. The controller shall include all hardware and software required for communications with the system controller. An individual zone controller shall be dedicated for <u>each</u> zone terminal device. Individual zone controllers are not required for constant volume duct reheat coil applications, but may be provided at Temperature Control Contractor's option.

B. Programs: The control program shall reside in the zone controller. The application program shall be maintained in ROM. The default database, i.e. setpoints and configuration information, shall be stored in EEPROM. Controllers requiring local setting of potentiometer or dip switches for control strategies are not acceptable. No batteries can be used for memory protection.

C. Stand-Alone: Controllers requiring the application or database to be downloaded from a host or share processing with a "master controller" shall not be acceptable. After a power failure the zone controller must run the control application using the current setpoints and configuration.

D. Communications: Communication to the system controller shall be 9600-baud asynchronous.

E. Input-/Output: Each zone controller shall have the necessary quantities of inputs and outputs for the selected duty. Inputs shall be individually electrically isolated from other inputs, outputs, communications, and power. All inputs shall feature an auto-calibrate function to eliminate sensing errors.

F. Connections: All electrical connections shall be made to the combination terminal strip and base assembly. To ensure long term reliability, all electrical terminations shall be screw type.

G. The logic card, containing all active electrical components, shall be easily installable and removable from the wiring base, without the use of tools or the removal of any electrical wiring. Products that require disconnection of wiring from logic card before removal will be required to supply and install a quick disconnect type inter-connection.

H. All controllers shall be interoperable controllers bearing the applicable BACnet logo on each controller that is provided.

2.10 ZONE CONTROLLER SOFTWARE

A. The zone controller software shall be provided with the capabilities required by the specific application.

B. Each input, output or calculation result shall be capable of being assigned to the network controller for system networking.

2.11 LOCAL CONTROLLER HARDWARE

A. General: The Local Controllers shall be a local control loop microprocessor-based controller installed at each mechanical system; i.e., air handling unit, heating boiler, chiller. The controller shall execute local control sequences, independent of a workstation. All control loops and setpoints shall be stored in EEPROM or other non-volatile field reprogrammable memory. Each controller shall be addressable by a workstation or a portable laptop computer. Where local controllers are used for constant volume duct reheat coil applications, group reheat zones to a local controller by floor, air handling unit, service, etc.

B. Scan: Controller shall continuously scan and maintain the most recent data in EEPROM for retrieval by a remote workstation and by the local controller software programs.

C. Isolation: Control, communication, and power circuits for each controller shall be individually electrically isolated to protect against transients, spikes, and power surges. All inputs and outputs shall be individually optically isolated from other inputs and outputs, power, communication, and field wiring. Optical isolation shall be provided either as an integral component of the controller or provided as a separate interface device between the controller and field wiring.

D. Servicing: For ease of servicing, each Controller shall consist of a removable plug-in circuit board. Products which require disconnection of wiring from the local controller logic card before removal shall supply and install a quick disconnect type interconnection.

E. All controllers shall be interoperable controllers bearing the applicable BACnet logo on each controller that is provided.

F. Database: All field control database shall be entered, changed or downloaded to the local controllers via a portable service tool or system workstation.

G. Auto-Calibration: All inputs shall feature an auto-calibrate function to eliminate sensing errors.

H. Input/output Modules: Provide the following input/output capabilities:

I. Universal inputs which can accept industry standard analog signals (4-20 mA, 0-5 VDC, etc.) and binary contact closures:

1. Digital outputs may be latched or momentary contact type.
2. Analog outputs shall have a 1% resolution over total output span of 100%.

2.12 LOCAL CONTROL SOFTWARE

A. General: Provide complete controller software to execute all mechanical system local loop controls functions.

B. Control Parameters: The software blocks in the local controller shall produce all of the necessary reverse acting and/or direct acting PI^2 signals as required by the control sequence. The proportional and integral values which make up the PI^2 output value shall be readable and modifiable, at the system workstation or the portable service tool to facilitate tuning of control loops.

C. Networking: Each input, output, or calculation result shall be capable of being assigned to the system controller for system networking.

D. Programming Functions: Provide the following standard temperature control loop programming functions:

1. Control Block Programming.
2. PI^2 or PID Control.
3. Serial Load Staging.
4. Binary Load Staging.
5. Analog Load Staging.
6. Master-Submaster Routines.
7. Anti-Windup for Integrated Loops.
8. Weekly/Daily/Holiday Scheduling.
9. Optimum Start/Stop Programming.
10. Automatic Trending with Adjustable Sample Rates.

2.13 SYSTEM CONTROLLER HARDWARE

A. General: The system controller shall be a microprocessor based, multi-tasking real time system controller that provides advanced system programming, uplink and downlink communication, polling and other supervisory functions for zone and local controllers. Provide the system

controller with a minimum 9600 baud auto-dial auto-answer modem for remote network access and remote alarm reporting.

B. Operating Environment: The control shall be capable of operating in an environment of 32° to 122°F and 10 to 90% relative humidity non-condensing.

C. Power Loss/Restart: The controller shall be tolerant of power failures. Memory shall be non-volatile or unit shall hold memory of to 30 days minimum on back-up batteries. When a power failure has occurred and power (normal or emergency) is restored, automatically and without operator intervention, the controller shall execute the following restart procedures:

1. Come on line.
2. Update all monitored functions.
3. Implement special building start-up strategies as required.
4. Resume operation based on current time and status.

D. Stand-Alone: The controller shall be a true no-host system that does not require a PC or "Host" computer to perform any control functions or communications.

E. Isolation: Field communication ports shall be individually electrically isolated to protect against transients, spikes, and power surges. The ports shall be optically isolated from each other, the controller circuit board and from power wiring. Optical isolation shall be provided either as an integral component to the controller or provide as a separate interface device between the controller and field wiring.

F. Self Diagnostics: The controller shall contain in this program, a self-test procedure for checking communications and verify the functionality of the CPU memory and database.

G. The system controller shall be the integration point for ASHRAE Standard 135-1995 BACnet MS/TP communication protocols. The system controller shall also provide all tools for Java enabled Web browser access via the local area networks (Intranet) and wide area networks (Internet).

H. Graphical User Interface (GUI):

1. The GUI shall be completely icon driven, multi-tasking and employing a graphical operating environment. The GUI shall not only be for real-time access to any system(s) on the LAN but shall also allow the operator an easy method of information management. Information management shall mean the massaging and manipulation of any system real time or historical data into integrated applications such as report generators, spreadsheets, X/Y charts, database managers, etc. Complete file management and data transfer, such as copying, moving files, automatic and manual means of "cutting and pasting" of data items from one application to another shall be provided as an integral part of this GUI. This GUI shall be completely Windows "compliant":

a. Menu and System Access:

1) This GUI shall provide an easy and absolute method of menu and system access. The menu system shall provide the entry point into the entire GUI array of applications and programs. All the GUI programs and Windows programs shall be accessible through this menu system.

2) This menu system shall be able to call any operator specific menu or menus allowing complete versatility in how the menu structure is designed and used.

b. System Security:

1) System security shall be on an application by application basis. During the setup or editing of a particular user the owner shall be able to enable or disable the use of any application or function within an application for each user of the system. Each user security access record shall list each of the applications to which the user has access and the functions that are permitted from within each of these applications. The users shall be assigned discrete passwords in order to have access to any particular application or function within the system.
2) As well as application protection each user shall be assigned to a personalized menu (see Menu and System Access). This shall allow for each user to have their own discrete menu system for access into the various applications and dynamic graphic screens.

c. Dynamic Graphics:

1) The dynamic graphic portion of this GUI shall allow the operator to access any system information via a system penetration method. System penetration shall allow the operator to begin at an entire site plan and then zoom in to a particular area for closer inspection and then further zoom in on this area and so on until the detailed color graphic display of a desired portion of the facility is represented.
2) As a minimum a graphic screen shall be designed showing the building, each floor, each major piece of mechanical equipment within each building that is being monitored/controlled, all of which will display the data for each area dynamically.
3) Dynamic point display shall be user selectable from at least the following options: standard text readout, font, style, size, foreground and background colors, border style, plus discrete movement animation allowing animation displays for items such as dampers, gauges, fans, switches, lights, alarm activity, etc.
4) Each mechanical and electrical system that is monitored/controlled by the system shall have a unique dynamic color graphic. The display will be provided by the control contractor and approved by the engineer.
5) The graphical user interface shall allow the user to easily create new displays and modify existing displays. A library of standard HVAC equipment, control devices, mechanical systems, tables, lines, circles, rectangles, squares, arrows, etc. shall be provided to allow easy implementation of the changes/additions to the system.
6) The program shall allow any standard JPG or GIF file to be displayed with dynamic data overlaid on to the display.

d. Centralized Scheduling and Modification:

1) Calendars shall be provided for displaying and modification of any of the controller's time clock functions. Holidays and special functions shall be

clearly marked on the calendar. Changes shall be permanent or, for one time or multiple occurrences. Global changes shall be allowed for similar schedules.

e. Alarm Annunciation:

1) Upon the incidence of an alarm an alarm window shall be displayed showing the point in alarm, the time and date of the alarm and a user - selected predefined alarm message (and optionally printed to a user defined printer, printers and/or dumb terminal devices). Alarms shall be displayed regardless of the application in use including any Windows applications. The program shall display the unacknowledged alarms. The user shall be able to selectively enable or disable the alarm reminder in the event there are unacknowledged alarms.
2) Acknowledgment of alarms shall be from an alarm "pop-up" display and/or from a separate alarm summary. Acknowledgment shall be by a specific event, date range, class, or specific alarm definition and condition. Upon acknowledging the alarm, the name of the operator acknowledging the alarm and the time and date will be associated with the acknowledgment. This data will be stored to the alarm history file and printed to the chosen printers or terminal devices.
3) Automatic or manual display of associated dynamic graphic screens shall be provided for each alarm upon the alarm occurrence.
4) The user shall be automatically placed back to the application or graphic in use at the time of alarm occurrence upon exiting the alarm handling mode.
5) A current alarm summary shall be provided which will dynamically display only alarms that are currently in alarm. As alarms are returned from their respective alarm states the current alarm summary shall be dynamically updated to reflect the change.

f. Trend Management:

1) The GUI shall automatically perform time based periodic collection of real time point data and subsequently store it to the systems hard disk.
2) Storage and manipulation of sampled points shall only be limited by disk space. Sampling rates shall be user selectable from instantaneous (once a second) to longer periods of time such as one week. Collection of data shall be user selectable to start and stop on specific times and dates.
3) Charting of the trend data shall be an integral part of the trend management program. Third party graphing packages such as Excel or Lotus 123 shall not be required to implement this program. Multiple points shall be capable of displaying on the same chart. Multiple X/Y charts may be run simultaneously displaying either real time data (instantaneous) or historical. X/Y scaling shall be either automatic or user selectable for any chart displayed, each chart may have different scaling. X scales shall be user selectable allowing for display of data over a wide range of times and dates. Display of multiple years of data shall be allowed. The chart display shall be capable of displaying a window of time for multiple years.

g. Multi-tasking:

1) The GUI shall be capable of true multi-tasking capabilities. The user shall be able to use other non-related programs while still running all GUI applications with no interruptions. This shall include the use of real time data in other applications.

h. The user interface shall employ Web browser-like functionality for ease of navigation. This interface shall include, but not be limited to, forward/backwards buttons, home button and a context sensitive locator line (similar to a URL line).

i. Graphic screens on the Web Browser client shall support hypertext links to other Web pages on other Internet or Intranet sites.

j. User log-on identification and passwords shall use Java authentication techniques to prevent unauthorized access.

2.14 SYSTEM CONTROLLER SOFTWARE

A. General: The network controller software shall be multi-tasking, menu-driven, in English language. The software shall operate on a database comprised of control blocks which resemble control hardware devices (receiver controllers, gradual relays, higher or lower of two pressure relays, time delay relays, etc.). The Controls Contractor shall configure these control blocks to attain the proper sequence of control. The user shall be able to add, delete, or modify all control blocks on-line as required.

B. Passwords: Provide a minimum of multiple levels of user definable passwords.

C. Help Menu: On-line location sensitive help shall be provided for each menu item, describing the consequences of making the highlighted menu selection.

D. Login: A login message shall be displayed every time the workstation is connected to a network controller.

E. Backup and Restore: The database in each network controller shall be uploaded to the System Workstation, for archival purposes, and shall be re-downloaded to each network controller at any time. Operating system changes, parameter changes, upgrades and enhancement for network controllers shall be downline loadable from the System Workstation, or via dial-in from a remote location.

F. Programming Functions: The software blocks shall provide all the necessary mathematics, logic, utility, and control functions necessary for proper sequence of control. These functions shall be contained in the network controller operating system to be available in any combination for field programming the unit through RAM memory. As a minimum, these routines shall include, but not be limited to, energy management strategies such as:

1. Time or Event Based Scheduling.
2. Adaptive Optimum Start/Stop.
3. Demand Limiting/Load Shedding.
4. Enthalpy Control.
5. Hot Water/Outdoor Air Reset.
6. Run Time Totalization.
7. Alarm Detection and Dial Out.
8. Night Setback.

9. Historical Trending.

G. Alarms: The network controller shall be capable of comparing analog and digital readings to predetermined high and low limits and annunciate each time a value enters or returns from an alarm condition. Unique high and low limits shall be supplied for each analog point in the system. The system shall be capable of suppressing selected alarm reporting when the primary equipment from which the alarm point is based is in the inactive state. The alarm features of the network controller software shall, as a minimum, provide the following:

1. Digital, Analog, and Hi/Lo settings and deadband.
2. Sliding Alarm Limits.
3. Conditional Alarming.
4. Alarm inhibiting through feedback loop.
5. Fluttering Alarm Suppression.
6. Separate Tailored Alarm Messages for each alarm.
7. Auto dial of any alarm condition to a minimum of 10 phone numbers.

H. Communication Diagnostics: The network controller software shall be programmed for self-diagnosing of failure, automatically without query by the operator. In the event of communications failure or limited power failure, the system shall be capable of both notifying a local operator of the specific occurrence, as well as auto dialing the condition to a remote site. Auto-dial out shall be configurable to repeat the alarm while the situation remains unattended and unacknowledged. In addition to automatic self-diagnostics, communications statistics on zone and general application controller communications shall be maintained. These statistics shall tabulate total communications attempted versus successful and unsuccessful communications by unit number. The option to reset communications statistics to zero (0) at any time shall be provided.

I. Interfaces to Other Manufacturer's Equipment: Where specified, each Network Controller shall be equipped with standard software blocks with which to interface to other manufacturer's equipment. The software blocks shall be defined by the Controls Contractor to read/write analog values and digital status to/from other manufacturer's equipment for alarm, trend, operator advisory, graphic display and other system uses. Communications between the Network Controller and other manufacturer's equipment shall occur in the same manner and with the same software as that used for communications with Dedicated and General Application Controllers.

J. The software shall employ object-oriented technology for representation of all data and control devices within the system. In addition, adherence to industry standards for ASHRAE BACnet is required to assure interoperability between control system manufacturers. The control contractor must provide a PICS document showing the installed system’s BACnet compliance level of 3.

K. The software must incorporate the ability to access all data using Java enabled browsers without requiring proprietary operator interface and configuration programs.

L. The software shall allow alarms to be routed to E-mail messages and paging services.

M. Access to the system controller shall be via the Internet from a remote location and from a local computer operator’s station (when specified) by direct connection to an Ethernet LAN. The control contractor shall provide a connection to the Internet to enable this access via high-speed

modem or via the Intranet to a corporate server providing access to an Internet Service Provider. The owner shall pay monthly access charges for the connection and service provider.

2.15 OPERATOR INTERFACE STATION

A. Provide an operator workstation and locate as directed by the owner. The workstation shall include the following:

1. Laptop (minimum requirements):

   a. Latest Intel processor – confirm with HVAC dept.
   b. 100 GB capacity hard disk drive
   c. 7200 rpm hard disk drive speed
   d. 4 GB system RAM
   e. 1 serial port, PCI Network Card
   f. Intel Pro/Wireless network card
   g. 17” wide format screen
   h. 3 USB 2.0 ports
   i. PCMI slot
   j. CD/CD-RW/DVD-RW drive
   k. Operating System – confirm with HVAC dept.

2. Desktop (minimum requirements):

   a. Latest Intel processor – confirm with HVAC dept.
   b. 180 GB capacity hard disk drive
   c. 7200 rpm hard disk drive speed
   d. 4 GB system RAM
   e. Dedicated 1 GB video RAM
   f. Internal 10/100 Network card
   g. 3 USB 2.0 ports
   h. PCI Audio
   i. CD/CD-RW/DVD-RW drive
   j. 19” WSXGA monitor
   k. 64-bit Operating System
   l. Operating System – confirm with HVAC dept.
   m. Surge Protector

2.16 WIRING AND CONDUIT

A. All wire will be copper and meet the minimum wire size and insulation class listed below:

Wire Class	Wire Size	Isolation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge Std.	600 Volt
Class Two	18 Gauge Std.	300 Volt
Class Three	18 Gauge Std.	300 Volt
Communications	Per Mfr.	Per Mfr.

B. Power and Class One wiring may be run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit.

C. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.

D. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum 1/2-inch galvanized EMT. Compression fittings shall be used for interior locations and watertight compression fittings for exterior locations. Provide conduit seal off fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.

E. Flexible metallic conduit (max. 3 feet) shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.

F. Junction boxes shall be provided at all cable splices, equipment terminations, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location J-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.

G. Where the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings. EXCEPTION: Any wire run in suspended ceilings that is used to control outside air dampers or to connect the system to the fire management system shall be in conduit.

2.17 ENCLOSURES

A. All controllers and field interface panels shall be mounted in new enclosures unless otherwise stated in this specification.

B. All outside mounted enclosures shall meet the NEMA-4 rating.

PART 3 - EXECUTION

3.01 PROJECT MANAGEMENT

A. Provide a project manager who shall, as a part of his duties, be responsible for the following activities:

1. Coordination between the Contractor and all other trades, Owner, local authorities, and the design team.
2. Scheduling of manpower, material delivery, equipment installation and checkout.
3. Maintenance of construction records such as project scheduling and manpower planning and AutoCAD for project co-ordination and project record drawings.

3.02 SYSTEM SETUP AND INSTALLATION

A. System setup and installation shall include but is not limited to the following:

1. Database entry and database setup of all input and output points, including alarm printouts with individual alarm messages, as described on the input/output point list.
2. Programming and full setup of all sequences described in the sequence of operation section of the specification as shown in 230993 - Sequence of Operation & Points List.
3. Complete checkout and testing of all functions, operations and features of the building automation system as described in this specification including, but not limited to, all features and functions utilized in the system setup as well as features and capabilities of the software and hardware described as provided and installed but not implemented or used at this time.

B. Pre-Programmed Trend Plots:

1. The Temperature Control Contractor shall add a pre-programmed trend plot at the system workstation GUI for all RTUs and VAVs. Trend plot shall contain a data entry box and adjoining “trend plot” button so user can immediately display a 24-hour trend plot (5-15 min interval) for any day in the preceding year. Include all unit and space temperature sensors; all unit, space and building pressure sensors; outside air temperature sensor; all component/stage on/off status; fan speed; damper positions and other pertinent information.

3.03 WIRING INSTALLATION METHODS

A. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings and equipment details. Install electrical components and use electrical products complying with requirements of applicable Division 26 sections of these specifications.

B. The term "control wiring" is defined to include the providing of wire, conduit, and miscellaneous materials as required for mounting and connecting electric or electronic control devices as follows:

1. Consist of wiring in pilot circuits of contractors, starters, relays, etc., and wiring for valve and damper operators.
2. For single phase devices where power current passes through controller, wiring between controller and device shall be considered control wiring; wiring to device from electric panel shall be considered power wiring.

C. Install control wiring system in conduit for electric/electronic control systems. Conceal wiring/conduit, except in mechanical rooms and areas where other conduit and piping are exposed. UL plenum rated cable shall be allowable in air plenums as approved by local codes. All control wiring shall be installed in a neat and workmanlike manner parallel to building lines with adequate support. Provide shielded cabling where required to prevent noise from being superimposed on control system wiring. Both conduit and plenum wiring shall be supported from or anchored to structural members. Conduit or plenum wiring supported from or anchored to piping, duct supports, the ceiling suspension system, or the electrical conduits is not acceptable. Wiring buried in slab on grade concrete or explosion proof areas shall be in rigid metal conduit. Provide adequate strain relief for all field terminations.

D. Number-code or color-code conductors, excluding those used for individual zone controls, appropriately for future identification and servicing of control system.

E. All line voltage power wiring required because of substitution of equipment specified in this section, shall be provided by this section.

3.04 CONTROL DEVICE LOCATIONS

A. Adjustable sensors and thermostats shall be mounted according to the requirements of the Americans with Disabilities Act (ADA) and the American National Standards Institute (ANSI) requirements. The contractor shall submit coordination documents to the architect indicating intended sensor/thermostat locations including intended mounting heights for architect review and approval. Upon completion of the architect's comments, the documents shall be submitted to the mechanical engineer for final review.

Remote control devices not in local panels shall be accessible for adjustment and service – below 7' above finished floor whenever possible.

B. Locate all temperature control devices wired under Division 26.

C. Local control enclosures shall be mounted at eye level for accessibility and service, and located within 50 feet of the system served, unless otherwise shown on the plans.

3.05 IDENTIFICATION

A. All control equipment shall be clearly identified by control shop drawing designation as follows:

1. Control valves and damper actuators - brass tags or engraved bakelite tags
2. Other remote-control devices - metal tags or laser printed, adhesive backed, metalized polyester film labels.
3. Control Enclosures - engraved nameplate with panel number and system served.
4. Control Conduit Junction Boxes - Painted medium blue.
5. All thermostats and temperature sensors shall be clearly marked with an engraved nameplate as to which device it serves (VAV terminal, cabinet unit heater, FTU, etc.). Final device designations shall be coordinated with owner prior to nameplates being engraved.

3.06 MOUNTING AND INSTALLATION PRACTICES FOR DEVICES

A. Well-mounted sensors will include thermal conducting compound within the well to insure good heat transfer to the sensor.

B. Actuators will be firmly mounted to give positive movement and linkage will be adjusted to give smooth continuous movement throughout 100 percent of the stroke.

C. Relay outputs will include transient suppression across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.

D. Water line mounted sensors shall be removable without shutting down the system in which they are installed.

E. Outdoor air sensor shall be placed in a location approved by the engineer.

3.07 LOCAL CONTROL PANELS

A. All relays, switches, transducers and other field interface devices, for equipment located within the mechanical equipment rooms, shall be panel mounted. Panels shall be NEMA type suitable for applications as required with hinged door and key-lock latch. Size for 20% spare mounting capacity.

B. Manual switches and indicating devices shall be flush-mounted on the panel face. Provide engraved bakelite or lithographed metal nameplates for all items on the panel face with white 1/2-inch-high letters on a black background. Paper or embossed labels are not acceptable.

C. Mount internal components securely on steel removable sub-panels. Each component shall be individually labeled with function and device identification, as shown on the control shop drawings. Label information shall be printed with a laser printer on adhesive backed metalized polyester film. Paper or embossed labels are not acceptable.

D. Interconnections between internal and face-mounted devices pre-piped and wired with color-coded tubing/conductors shall be neatly installed in plastic tray and/or tie-wrapped. All wiring within the panel shall be run in wiring tray in accordance with NEMA and UL standards, and shall meet all local codes. Terminals for field connections shall be UL listed for 600V service, individually identified per control shop drawings, with adequate clearance for field wiring. Control air terminations for field connection shall be individually identified control shop drawings.

E. Provide a convenience 120 VAC receptacle in each panel, a fused on/off power switch, and main air gauge for control power sources to each local panel. Provide a final as-built control drawing, reduced, laminated, and mounted inside of the panel door.

3.08 MOUNTING AND INSTALLATION PRACTICES FOR ZONE AND LOCAL CONTROLLERS

A. Controllers are to be mounted vertically.

B. The 120 VAC power wiring to the network of Controllers shall be a dedicated run, with a separate breaker. Each run will include a separate hot, neutral, and ground wire. The ground wire will terminate at the breaker panel ground. This circuit will not feed any other circuit or device.

C. Utilize a true earth ground. Do not use a corroded or galvanized pipe, or structural steel.

D. Controllers will be clearly labeled with the model number of the controller. In addition, all status lights will be identified with labels to indicate their function.

3.09 SOFTWARE INSTALLATION

A. The Contractor shall provide all labor necessary to install, initialize, start-up, and debug all system software as described in this section. This includes any operating system software or other third-party software necessary for successful operation of the system.

3.10 SYSTEM ACCEPTANCE

A. General: The system installation shall be complete and tested for proper operation prior to acceptance testing for the Owner's authorized representative. A letter shall be submitted to the Engineer requesting system acceptance. This letter shall certify all controls are installed and the software programs have been completely exercised for proper equipment operation. Acceptance testing shall commence at a mutually agreeable time within ten (10) calendar days of request. When the test procedures have been demonstrated to the Owner's representative and pass, the system will be accepted. The One-Year Warranty Support Plan shall begin at this time.

B. Acceptance Test Procedures: DDC control panels shall be demonstrated via a functional end-to-end test. Prior to an acceptance test review by the Engineer, the contractor shall submit a point by point checklist to the Engineer with descriptions of how the following tests were performed. Such that:

1. All output channels shall be commanded (on/off, stop/start, adjust, etc.) and their portion verified.
2. All analog input channels shall be verified for proper operation.
3. All digital input channels shall be verified by changing the state of the filed device and observing the appropriate change of displayed value.
4. Automatic control operation of PID control loops shall be verified by introducing an error or change into the system and observing the proper corrective system response.
5. Automatic control operation of sequences of operation shall be verified by introducing an error or change into the system and observing the proper corrective system response.
6. Selected time and setpoint schedules shall be verified by changing the schedule and observing the correct response on the controlled outputs.
7. Communication with each DDC control panel shall be demonstrated.
8. All available and specified system reports and logs shall be demonstrated at the system workstation.
9. Correct system start-up and shutdown procedures shall be demonstrated.
10. All controllers shall be demonstrated to operate in a standalone mode.
11. Workstation Operator commands will be explained and demonstrated.
12. If any point or sequence should fail testing, perform necessary repair action and retest failed point and all interlocked points.

C. Project Record Documentation: After a successful acceptance demonstration, submit project record drawings of the completed project for final approval. After receiving final approval, supply three (or as specified in Division 01) complete project record drawing sets (maximum ANSI "D" size), together with AutoCad diskettes to the owner. The original master site software license and disposition of any required software keys shall be included.

D. Operation and Maintenance Manuals: Submit six (6) copies (or as specified in Division 01) of operation and maintenance manuals. Include the following:

1. Update all drawings and data required in the control submittal to a finalized form and add the following information:

    a. An operator's manual which will include detailed instructions for all operations of the system. Include detailed instructions for accessing and using the graphical user interface.
    b. A programmer's manual which will include all information necessary to perform programming functions.
    c. A language manual which will include a detailed description of the language used and all routines used by the system.
    d. An operator's reference table listing the addresses of all connected input points and output points. Settings shall be shown where applicable.
    e. Complete program listing file and parameter listing file for all programs.
    f. A copy of the warranty.
    g. Operating and maintenance cautions and instructions.
    h. Operation of Graphical User Interface.
    i. Recommended spare parts list.

3.11 TRAINING

A. Contractor shall provide to the engineer a training class outline prior to any scheduled training.

B. Training sessions shall be provided for the Owner's personnel by factory trained control engineers and technicians.

C. The control contractor shall conduct four - four (4) hour on-site training sessions as a course for designated owner's personnel in the maintenance and operation of the control system. One course shall be given prior to system acceptance and one additional course shall be provided during the Warranty Support Plan period.

D. The course shall include instruction on specific systems and instructions for operating the installed system on include as a minimum:

    1. HVAC system overview
    2. Operation of Control System
    3. Function of each Component
    4. System Operating Procedures
    5. Programming Procedures
    6. Maintenance Procedures

3.12 SPARES

A. Provide one each of the following spare parts:

    1. Room Sensor
    2. Zone Controller Board (one of each type)
    3. Local Controller Board (one of each type)

3.13 EXPANSION

A. System Controller Hardware and Software must be provided with expansion capabilities for the addition of control, points, etc. for future remodel of remainder of building.

PART 4 - END OF SECTION 230923

A.

SECTION 230993 – SEQUENCES OF OPERATIONS - DDC

PART 1 - GENERAL

1.01 SUMMARY:

A. All HVAC Systems shall be controlled with Direct Digital Control (DDC) according to the point list contained in this specification. All controllers shall be capable of stand-alone operation and shall be interfaced to the system controller(s) and building graphical user interface. Additional points or software programming not listed in the point list but which are required to meet the specified sequences of operation shall be provided.

1.02 SUBMITTALS

A. See Section 230923 for submittal requirements specific to the temperature controls scope of work.

1.03 SETPOINTS

A. All setpoints shall be adjustable. All control loops shall utilize PI^2 or PID control algorithms unless otherwise specified in the sequence of operation.

1.04 ALARMS

A. All zone controller, local controller, and system controller communication failures shall be capable of being annunciated at the system controller(s) and system graphical user interface as an alarm. All specified alarms shall be capable of being annunciated at the system controller(s) and system graphical user interface with alarm messages tailored for the specific alarm by system type and device type.

1.05 NORMAL POSITIONS

1. Outside air damper - Closed
2. Return air damper - Open
3. Exhaust air damper - Closed
4. Hot water valve - Open
5. Chilled water valve - Closed
6. In-duct Heating Valve - Open

1.06 CONTROL SYSTEM KEY

Symbol	Description
AUX	Auxiliary Contact
AQT	Air Quality Transmitter

Symbol	Description
CR	Control Relay
DM	Damper Motor
FA	Fire Alarm
FT	Flow Transmitter
FS	Flow Switch
FZ	Low Limit Thermostat
HOA	Hand/Off/Auto
IS	Current Switch
IT	Current Transmitter
PDT	Pressure Differential Transmitter
PDS	Pressure Differential Switch
PT	Pressure Transmitter
PS	Pressure Switch
SD	Smoke Detector
S/F	Smoke/Fire
S/S	Start/Stop
SC	Smoke Control
TS	Temperature Switch
TT	Temperature Transmitter
VFD	Variable Frequency Drive
VM	Valve Motor

1.07 POINTS LISTS

A. Refer to “Control Diagrams” on the construction drawings, for points lists.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 UNDER DEVELOPMENT

END OF SECTION 230993

SECTION 232000 - HVAC PIPES, VALVES & PIPE SPECIALTIES

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Types of equipment specified in this section include the following:

1. Pipes and Pipe Fittings.
2. Valves.
3. Pipes Specialties.
4. Expansion Devices.
5. Supports and Anchors.
6. Meters and Gauges.

1.02 SUBMITTALS

A. Provide the following submittals:

1. Pipe & Fittings.
2. Soldering and Brazing Material.
3. Valves.
4. Backflow Preventers.
5. Escutcheons.
6. Strainers.
7. Dielectric Fittings.
8. Fire Barrier Sealants.
9. Sleeve Seals.
10. Hangers and Supports.
11. Shields and Saddles.
12. Thermometers.
13. Pressure Gauges.

1.03 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.
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.

PART 2 - PRODUCTS

2.01 PIPE AND FITTINGS

A. Shall be of material, weight, ASTM and ANSI Designation, and pressure ratings as follows unless specifically excepted otherwise.

B. Hydronic Piping (Heating Water, Chilled Water & Condenser Water):

1. Pipe Size 2" and Smaller: Black steel pipe; ASTM A-53; Schedule 40; Class 125 cast-iron fittings with threaded joints; 150-pound malleable fitting.
2. Pipe Size 1 ½" and Smaller: Copper pipe; Type L, hard-drawn temper; wrought-copper fittings with soldered joints (95-5 tin antimony solder).
3. Pipe Size 2" and Larger: Copper Pipe; Type L, hard drawn temper; wrought copper fittings with brazed joints.
4. Pipe Size 2½" thru 6": Type L hard drawn copper tubing ASTM B88-70 with Gruvlok copper method full flow wrought copper with ends formed to Gruvlok copper prep roll or groove specs to accept Gruvlok 7400 couplings and 7012 flanges, or equal by Victaulic.
5. Pipe Size 2 1/2" and Larger: Black steel pipe; ASTM A-53; Schedule 40; 150 wrought-steel buttwelding fittings with welded joints.
6. Pipe Size 2 1/2" and Larger: Black steel pipe; Schedule 40; grooved fittings with mechanical grooved couplings. (Acceptable Manufacturers: Central, Gruvlok, and Victaulic.)
7. 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" minimum thickness of flexible unicellular insulation.
8. Underground Piping All Sizes: Black steel pipe, ASTM A-53, Schedule 40, Class 150 with wrapping: machine wrap, 50% overlap wrap with polyvinyl chloride tape. Hand wrap fittings using 100% overlap wrap extending 6" beyond fitting onto wrapped pipe.

2.02 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-Copper-Zinc Solder: ASTM B260-62T, Bag-2.

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 for cast- iron flanges; raised-face for steel flanges, unless otherwise indicated.

2.03 VALVES

A. General: 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. Valves shall be manufactured in accordance with all applicable M.S.S. Standards.

B. Sizes: Unless otherwise indicated, provide valves of same size as upstream pipe size.

C. Operators: Provide handwheels, fastened to valve stem, for valves other than quarter-turn. Provide lever handle for quarter-turn valves, 6" and smaller, other than plug valves. Provide one wrench for every 10 plug valves.

D. Acceptable Manufacturers

1. Gate Valves, Globe Valves and Swing Check Valves:

   a. Hammond/Milwaukee Valve Corp.
   b. Nibco, Inc.
   c. Watts.

2. Drain Valves:

   a. Apollo.
   b. Hammond/Milwaukee Valve Corp.
   c. Nibco, Inc.

3. Ball Valves:

   a. Apollo.
   b. Hammond/Milwaukee Valve Corp.
   c. Nibco, Inc.
   d. Watts Co.

4. Butterfly Valves:

   a. Apollo.
   b. Centerline.
   c. DeZurik Co.
   d. Keystone.
   e. Nibco, Inc.

5. Wafer Check Valves:

   a. Centerline.
   b. Crane/Jenkins/Stockham.
   c. Nibco, Inc.

d. Mission.
e. Techno.
f. Victaulic (Groove piping approved locations only).

6. Lift Check Valves:

a. Hammond/Milwaukee Co.
b. Nibco, Inc.
c. Stockham/Crane.

7. Balance Valve (2" and smaller Venturi Type):

a. Flowset-Flow Design Inc.
b. Gerand.
c. Griswold
d. Preso.

8. Balance Valve (2" and smaller variable CV orifice type):

a. Armstrong.
b. Bell & Gossett.
c. Nibco, Inc.
d. Tour – Anderson.

9. Balance Valve (2 1/2" and larger eccentric ball design):

a. Milliken.

10. Balance Valve (2 1/2" and larger plug valve type):

a. Dezurik.
b. Rockwell.

11. Balance Valve (2 1/2" and larger butterfly valve type):

a. Keystone
b. Nibco, Inc.
c. Griswold.
d. Flow Designs

E. Valve Features:

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. Flanged: Valve flanges complying with ANSI B16.1 (cast iron), ANSI B16.5, (steel), or ANSI B16.24 (bronze).
3. Threaded: Valve ends complying with ANSI B2.1.
4. Butt-Welding: Valve ends complying with ANSI B16.25.
5. Solder-Joint: Valve ends complying with ANSI B16.18.

6. Flangeless: Valve bodies manufactured to fit between flanges complying with ANSI B16.1 (cast iron), ANSI B16.5 (steel), or ANSI B16.24 (bronze).

F. Valve Schedule:

1. General: Provide the following valves for various valve types referenced in Division 23 sections.
2. Gate Valves:

a. 2” and Smaller: 175 lb. SWP, bronze, screw-in bonnet, rising stem, solid wedge. Conform to MSS SP-80.

1) Threaded Ends:

a) Hammond/Milwaukee 148.
b) Nibco, Inc. T-154-A

2) Solder Ends:

a) Hammond/Milwaukee 149.
b) Nibco, Inc. S-154-A

b. 2” and Smaller: 175 lb. SWP, bronze screw-in bonnet, non-rising stem, solid wedge. Conform to MSS SP-80.

1) Threaded Ends:

a) Hammond/Milwaukee 105.

2) Solder Ends:

a) Hammond/Milwaukee 115.

c. 2-1/2” and Larger: Flanged ends, 175 lb. SWP, iron body, bolted bonnet, solid wedge, bronze mounted. Conform to MSS SP-70.

1) OS & Y:

a) Hammond/Milwaukee F-2885.

3. Globe Valves:

a. 2” and Smaller: 125 lb. SWP, bronze body, screw-in bonnet, integral seat, renewable disc. Conform to MSS SP-80.

1) Threaded Ends:

a) Hammond/Milwaukee 502.
b) Nibco, Inc. T-211-B.

2) Solder Ends:

a) Hammond/Milwaukee 1502.
b) Nibco, Inc. S-112-B.

b. 2” and Smaller: 125 lb. SWP, bronze angle body, screw-in bonnet, integral seat, renewable disc. Conform to MSS SP-80.

1) Threaded Ends:

a) Hammond/Milwaukee 504.

c. Flanged Ends; 2-1/2" and Larger: 1.25 lb. SWP, iron body, bolted bonnet, renewable seat and disc, bronze mounted. Conform to MSS SP-85.

1) Straight Body:

a) Hammond/Milwaukee F-2981.

4. Drain Valves:

a. 125 lb. SWP: Bronze body, screw-in bonnet, rising stem, composition disc, 3/4" hose outlet, provide cap and chain. Conform to ASSE 1005.

1) Threaded End:

a) Nibco, Inc. T-113-HC.

5. Ball Valves:

a. 2” and Smaller: 600 CWP / 150 SWP, bronze body, full port, bronze trim, 2-piece construction, TFE seats and seals.

1) Milwaukee BA-100/BA-150.
2) Nibco, Inc. T-585-70-66/S-585-70-66.
3) Apollo 77CL-100/77CL-200.

b. 2-1/2” thru 4": 400 CWP / 150 SWP, bronze body, full port, 2- or 3-piece body, PTFE seats with bronze trim.

1) Nibco, Inc. T-FP-600N.
2) Nibco, Inc. S-FP-600N.

c. 2” and Smaller: One piece, non-ferrous, bronze/brass flow measuring and balancing/shut-off valve combination. The flow element shall be a low loss/high signal Venturi type (± 2% accuracy) of one to ten rangeability, equipped with dual Schrader Type pressure test posts and caps. Balancing/shutoff valves shall be ball type with large diameter plated ball, teflon seats, blow out proof stem with teflon packing and packing nut. Full size handle, grip and memory stop. Entire assembly rated to 400 CWP and tested to 100% after assembly.

1) Provide one gauge kit consisting of Bellows Type meter capable of reading flow directly in GPM using magnetically attached transparent faces. Meter

equipped with 6 ft. hoses, Schrader Type end connectors, bleed and equalizing manifold and rugged plastic case with instructions.

2) Acceptable Manufacturers:

a) Gerand Co.
b) Flow Design-Flowset.
c) Preso.
d) Griswold (manually adjusted valves only).

d. 2 1/2" and Larger: Provide cast-iron body with ball centric or plug valve design. Locate downstream of all flow measuring stations or as recommended by manufacturer.

1) Acceptable Manufacturers:

a) Milliken - Ball Centric.
b) Dezurik - 400 Series (to 4").

e. 2 1/2" and Larger: Provide ductile iron or carbon steel, full lug type butterfly valve body with 2” extended neck. Steel body venturi with extended P/T test ports. EPDM gasket, stainless steel stem, nylon bearings and AL-bronze disc.

1) Acceptable Manufacturers:

a) Flow Design FlowSet
b) Nibco
c) Griswold

f. 2 1/2" and Larger: Provide ductile iron or carbon steel, full lug type butterfly valve body with 2” extended neck. Steel body venturi with extended P/T test ports. EPDM gasket, stainless steel stem, nylon bearings and AL-bronze disc.

1) Acceptable Manufacturers:

a) Flow Design FlowSet
b) Nibco
c) Griswold
d) Keystone

2.04 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 as determined by Installer 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.

B. Pipe Escutcheons:

1. 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.
2. Acceptable Manufacturers:

    a. Brasscraft.
    b. Dearborn.
    c. McGuire.
    d. Zurn.

C. Strainers:

1. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125 psi working pressure, with Type 304 stainless steel screens, with 3/64" perforations @ 233 per sq. in. as a minimum.

    a. Threaded or Sweat Ends, 4" and Smaller in Copper: Cast bronze body, screwed screen retainer with centered blowdown fitted with blowdown piped to nearest drain with valve.
    b. Threaded Ends, 2" and Smaller: Cast-iron or semi-steel body, screwed screen retainer with centered blowdown fitted with blowdown piped to nearest drain with valve.
    c. Threaded or Flanged Ends, 2-1/2" and Larger: Cast-iron or semi-steel body, bolted screen retainer with off-center blowdown fitted with blowdown piped to nearest drain with valve.
    d. Butt Welded Ends, 2-1/2" and Larger: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with blowdown piped to nearest drain with valve.
    e. Acceptable Manufacturers:

        1) Apollo.
        2) Hoffman Specialty ITT; Fluid Handling Div.
        3) McAlear Co.
        4) Metraflex Co.
        5) Mueller Co.
        6) Watts Regulator Co.
        7) Nibco, Inc.

D. Dielectric Fittings:

1. General: Provide standard products recommended by manufacturer for use in service indicated, which effectively isolate ferrous from non-ferrous piping (electrical conductance), prevent galvanic action, and stop corrosion.

    a. Dielectric unions and flanges shall conform to ANSI and have no flow restriction when assembled. Flanges shall be rated at 175 psi and unions at 250 psi.

        1) Acceptable Manufacturers:

a) Capital MFG.
b) Epco Sales, Inc.
c) Mueller Company.
d) Watts Regulator.

b. Clearflow dielectric waterway nipple, steel nipple with inert thermoplastic liner. Shall meet ASTM F-492-77.

1) Acceptable Manufacturers:

a) Perfection Corporation – Victaulic.

E. Fire Barrier Penetration Seals:

1. Provide seals for any opening through fire-rated walls, floors, or ceilings used as passage for mechanical components such as piping or ductwork.

a. Cracks, Voids, or Holes Up to 4" Diameter: Use putty or caulking, one-piece intumescent elastomer, non-corrosive to metal, compatible with synthetic cable jackets, and capable of expanding 10 times when exposed to flame or heat, UL-listed.
b. Openings 4" or Greater: Use sealing system capable of passing 3-hour fire test in accordance with ASTM E-814, consisting of wall wrap or liner, partitions, and end caps capable of expanding when exposed to temperatures of 250° F to 350° F, UL-listed.
c. Acceptable Manufacturers:

1) Electro Products Div./3M. (Fire Barrier Systems)
2) Mansville Products Corp.
3) Nelson; Unit of General Signal. (Flameseal)
4) Pipe Shield Incorporated.
5) STI.
6) Hilti – FS/One.

2.05 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". Reinforce top, either by structural angles or by rolling top over 1/4" steel rod. Provide hole, gasket, and flange at low point for watertight joint and 1" 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 gauges: 3" and smaller, 20 gauge; 4" to 6" 16 gauge; over 6", 14 gauge.
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.
4. Plastic-Pipe: Fabricate from Schedule 80 PVC plastic pipe; remove burrs.

C. Sleeve Seals: Provide sleeve seals in sleeve as follows:

1. Below grade in foundation wall or exterior walls above grade.

   a. Link seal.
   b. Innerlynx

2. Penetration below grade thru floor.

   a. Provide elastomeric joint sealant to maintain watertight and airtight continuous seal.

3. Penetrations thru walls, floors, or ceilings above grade.

   a. Intumescent fire stop.

2.06 RUBBER EXPANSION JOINTS

A. Construct of duct and butyl rubber with full-faced integral flanges, internally reinforced with steel retaining rings. Provide steel retaining rings over entire surface of flanges, drilled to match flange bolt holes, and provide external control rods.

B. Acceptable Manufacturers:

1. Keflex, Inc.
2. Metraflex Co.

2.07 EXPANSION JOINTS FOR GROOVED PIPING

A. General: For piping systems fabricated from cut grooved pipe and couplings, use one of the following methods for expansion compensation:

1. Combination Couplings and Nipples: Provide expansion joints constructed of cut grooved short pipe nipples and couplings, designed by manufacturer to suit intended service. Provide removable ties to hold joint compressed or expanded during piping fabrication, depending on application. Select couplings and gasket materials to match balance of piping system.
2. Slip-Type Expansion Joints: Provide slip-type expansion joints constructed of carbon steel pipe and couplings, designed by manufacturer to suit intended service. Select couplings and gasket material to match balance of piping system.

B. Acceptable Manufacturers:

1. Anvil.
2. Victaulic Co. of America.

2.08 PIPE ALIGNMENT GUIDES

A. General: Provide pipe alignment guides on both sides of expansion joints, and elsewhere as indicated. Construct with 4- finger spider traveling inside guiding sleeve, with provision for anchoring to building substrate.

B. Acceptable Manufacturers:

1. Anvil.
2. Hyspan Precision Products, Inc.
3. Metraflex Co.

2.09 HANGERS AND SUPPORTS

A. References:

1. ASTM B633 – Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
2. ASTM A123 – Specification for Zinc (Hot Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip.
3. ASTM A653 G90 – Specification for Steel Sheet, Zinc Coated by the Hot-Dip Process.
4. MSS SP58 – Manufacturers Standardization Society: Pipe Hangers and Supports – Materials, Design and Manufacture.
5. MSS SP69 – Manufacturers Standardization Society: Pipe Hangers and Supports – Selection and Application.

B. Quality Assurance:

1. Steel pipe hangers and supports shall have the manufacturer’s name, part number, and applicable size stamped in the part itself for identification.
2. Hangers and supports shall be designed and manufactured in conformance with MSS SP58.

C. Horizontal-Piping Hangers and Supports:

1. General: Except as otherwise indicated, provide factory- fabricated horizontal-piping hangers and supports selected by Installer to suit horizontal-piping systems. 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 baked on epoxy paint hangers and supports for copper piping systems.

D. Vertical-Piping Clamps:

1. 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 baked on epoxy paint clamps for copper-piping systems.

E. Hanger-Rod Attachments:

1. 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.

F. Building Attachments:

1. 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.

G. Finishes:

1. Indoor Finishes:

a. Hangers and clamps for support of bare copper piping shall be coated with copper colored epoxy paint. Additional PVC coating of the epoxy painted hanger shall be used where necessary.
b. Hangers for other than bare copper pipe shall be zinc plated in accordance with ASTM B633 or shall have an electrodeposited epoxy finish.
c. Strut channels shall be pre-galvanized in accordance with ASTM A653 G90 or have an electrodeposited epoxy finish.

2. Outdoor, High Humidity and Corrosive Area Finishes:

a. Hangers and strut for insulated piping in high humidity areas, including but not limited to: natatoriums, pool locker rooms and pool equipment rooms, shall be hot dip galvanized after fabrication by manufacturing in accordance with ASTM A123. All hanger hardware in high humidity areas shall also be hot-dip galvanized. Zinc plated or stainless steel hardware is not acceptable for these areas.
b. Hangers and struts located in outdoor or corrosive areas, including but not limited to corrosive chemical storage rooms, shall be electro-deposit epoxy finish with stainless steel hardware. (Does not apply to chlorine storage, the chlorine storage room hangers shall match the natatorium.)

H. Acceptable Manufacturers of Hangers and Supports:

1. B-Line Systems Inc.
2. Grinnel Corp.
3. Superstrut.
4. PHD, Inc.
5. Erico.

I. Saddles and Shields:

1. 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. Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation or manufacturer's pre-insulated type.
3. Protection Shields: MSS Type 40; of length per schedule below to prevent crushing of insulation. Provide coated projection shields on cold/ chilled water piping.

    a. Schedule:

Nominal Pipe or Tubing Size	Shield Length	Shield Gauge Thickness	Material
½" thru 3"	12"	18	Galvanized
4"	12"	16	Galvanized

4. Thermal Hanger Shields: MSS Type 40 Constructed of an insert of high density, 100 psi, water-proofed calcium silicate, encased in a sheet metal shield. Provide assembly of same thickness as adjoining insulation. The style of thermal hanger shield assembly shall be determined by shield manufacturer based on hanger type.
5. Acceptable Manufacturers:

    a. Pipe Shields, Inc.
    b. Value Engineering Products, Inc.

2.10 MISCELLANEOUS MATERIALS

A. Metal Framing:

1. Supplementary Structural Supports: Design and fabricate supports using structural quality steel bolted framing materials as manufactured by B-Line Systems. Channels shall be roll formed, 12 gauge ASTM A570 Grade 33 steel, 1 5/8" x 1 5/8" or greater as required by loading conditions. Submit designs for pipe tunnels, pipe galleries, etc., to Engineer for approval. Use clamps and fittings designed for use with the strut system.

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). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.

D. Trapeze Hangers:

1. Trapeze hangers shall be constructed from 12 gauge roll formed ASTM A570 Gr. 33 structural steel channel, 1 5/8" x 1 5/8" minimum. B-Line B22 strut or stronger as required.
2. Mount pipes to trapeze with 2 piece pipe straps sized for outside diameter of pipe, B-Line B2000 Series.
3. For pipes subjected to axial movement:

    a. Strut mounted roller support, B-Line B3126. Use pipe protection **shields or saddles** on insulated lines.
    b. Strut mounted pipe guide, B-Line B2417.

E. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.

F. Pipe 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.

2.11 GLASS THERMOMETERS

A. General: Provide glass thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.

B. Case: Die cast aluminum finished in baked epoxy enamel, glass front, spring secured, 9" long.

C. Adjustable Joint: Die cast aluminum, finished to match case, 180°F adjustment in vertical plane, 360 degrees adjustment in horizontal plane, with locking device.

D. Tube and Capillary: Organic filled "red" color, magnifying lens, 1% scale range accuracy, shock mounted.

E. Scale: Satin faced, non-reflective aluminum, permanently etched markings.

F. Stem: Copper-plated steel, or brass, for separable socket, length to suit installation.

G. Range: Conform to the following:

1. Hot Water: 30° - 240°F with 2°F scale divisions.
2. Chilled Water: 30° - 180°F with 2°F scale divisions.

H. Acceptable Manufacturers:

1. Ernst Gage Co.
2. Marshalltown Instruments, Inc.
3. Taylor.
4. Trerice (H.O.) Co.
5. Weiss Instruments, Inc.
6. Winters Thermogauge.

2.12 DIRECT MOUNT DIAL THERMOMETERS

A. General: Provide direct mount dial thermometers of materials, capacities, and range indicated, designed and constructed for use in service indicated.

B. Type: Vapor tension, universal angle.

C. Case: Drawn steel or brass, glass lens, 4-1/2" diameter.

D. Adjustable Joint: Die cast aluminum, 180 degrees adjustment in vertical plane, 360 degrees 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: 40° - 240°F.
2. Chilled Water: 30° - 180°F.

J. Acceptable Manufacturers:

1. Marsh Instrument Co.; Unit of General Signal.
2. Trerice (H.O.) Co.
3. Weiss Instruments, Inc.
4. Winters Thermogauge.

2.13 THERMOMETER WELLS

A. General: Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2" extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.

B. Manufacturer: Same as thermometers.

2.14 PRESSURE AND TEMPERATURE GAUGE CONNECTOR PLUGS

A. General: Provide temperature and pressure gauge connector plugs pressure rated for 500 psi and 275°F. Construct of brass and finish in nickel-plate, equip with 1/2" NPT fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8" O.D. probe assembly from dial type insertion thermometer or pressure gauge. Equip orifice with gasketed screw cap and retaining strap. Provide extension, length equal to insulation thickness, for insulated piping.

B. Acceptable Manufacturers:

1. Peterson Equipment Co.

2.15 PRESSURE GAUGES

A. General: Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.

B. Type: General use, 1% accuracy, ANSI B40.1 grade A, phosphor bronze bourdon type, bottom connection.

C. Case: Drawn steel or brass, glass lens, 4 1/2" diameter.

D. Connector: Brass with 1/4" male NPT. Provide protective syphon when used for steam service.

E. Scale: White coated aluminum, with permanently etched markings.

F. Range: Conform to the following:

1. Vacuum: 30" Hg - 15 psi.
2. Water: 0 - 100 psi.
3. Steam: 0 - 200 psi.

G. Acceptable Manufacturers:

1. Ametek/U.S. Gauge.
2. Marsh Instrument Co.; Unit of General Signal.
3. Marshalltown Instruments, Inc.
4. Trerice (H.O.) Co.
5. Weiss Instruments, Inc.
6. Winters Thermogauge.

2.16 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" female NPT on each end, and "T" handle brass plug.

B. Syphon: 1/4" straight coil constructed of brass tubing with 1/4" male NPT on each end.

C. Snubber: 1/4" 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.

PART 3 - EXECUTION

3.01 PIPE AND PIPE FITTING 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" misalignment tolerance.

B. Locate piping runs, except as otherwise indicated, vertically and horizontally (pitched to drain) and avoid diagonal runs wherever possible. 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" where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any. Where possible, locate insulated piping for 1" 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. 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.

D. Painting of Pipe: Paint all exterior steel piping (condenser, chilled water, etc.) with a rust inhibitor paint. Coordinate color with architect prior to painting.

3.02 PIPING SYSTEM JOINTS

A. General: Provide joints of type indicated in each piping system.

B. 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.

C. Braze copper tube-and-fitting joints where indicated, in accordance with ASME B31.

D. 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. Use only flux with no lead content. 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.

E. Weld pipe joints in accordance with recognized industry practice and as follows:

1. Weld pipe joints only when ambient temperature is above 0°F where possible.
2. Bevel pipe ends at a 37.5-degree 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" long welds; 4 welds for pipe sizes to 10", 8 welds for pipe sizes 12" to 20".
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; re-fabricate 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. Clean all welded joints and apply prime coat rust inhibitor.

F. Grooved joint piping systems shall be installed in accordance with the manufacturer's (Victaulic) guidelines and recommendations. All grooved couplings, fittings, valves and specialties shall be supplied by a single manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be supplied by the grooved coupling manufacturer. Grooved end shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove. A Victaulic factory trained field representative shall provide on-site training to contractor's field personnel in the installation of grooved piping products. Factory trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

G. 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.

3.03 INSTALLATION OF VALVES

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 all branch lines to isolate sections of piping whether shown or not. Branch lines will be considered any line connecting to the main piping. 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. Shutoff Valves: Install on inlet and outlet of each mechanical equipment item, and elsewhere as indicated.

C. Drain Valves: Install on each mechanical 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 hydronic piping system.

D. Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

E. Mechanical Actuators: Install mechanical actuators with chain operators where indicated. Extend chains to about 5' above floor and hook to clips to clear aisle passage.

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

G. Non-Metallic Disc: Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign material in piping system can be expected to prevent tight shutoff of metal seated valves.

H. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

I. Fluid Control: Except as otherwise indicated, install **ball, globe, and butterfly** valves to comply with ANSI B31.9. Where throttling is indicated or recognized as principal reason for valve, install **balancing, globe or butterfly valves**, or as indicated on the drawings.

J. Installation of Check Valves:

1. Swing Check Valves: Install in horizontal position with hinge pin horizontally perpendicular to center line of pipe. Install for proper direction of flow.
2. Wafer Check Valves: Install between 2 flanges in horizontal or vertical position, position for proper direction of flow.
3. Lift Check Valve: Install in piping line with stem vertically upward, position for proper direction of flow.

3.04 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" and smaller installed ahead of control valves feeding individual terminals. Where indicated, provide drain line from shutoff valve to plumbing drain, full size of blow down connection.

1. Locate Y-type strainers in supply line ahead of the following equipment, and elsewhere as indicated, if integral strainer is not included in equipment:

a. Pumps.
b. Steam traps serving steam main drips.
c. Temperature control valves larger than 2".
d. Temperature or pressure regulating valves.

C. Dielectric Fittings:

1. Contractor shall use dielectric nipples wherever possible.
2. Provide dielectric pipe fittings and isolators at all connections between dissimilar metals to control corrosion potential caused by galvanic or electrolytic action. Dielectric fittings shall be installed on hydronic systems only – do not use on steam or steam condensate systems.

D. Fire Barrier Penetration Seals: Fill entire opening with sealing compound. Adhere to manufacturer's installation instructions.

3.05 INSTALLATION OF FABRICATED PIPING SPECIALTIES

A. Drip Pans: Locate drip pans under piping passing over or within 3' 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" drain line to drain connection, and run to nearest plumbing drain or elsewhere 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 Architect/Engineer. 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 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. Extend floor sleeves 1/4" above level floor finish, and 3/4" 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 penetrations; both above and below grade.
3. Install steel-pipe sleeves except as otherwise indicated.

C. Sleeve Seals: Install in accordance with the manufacturer's requirements.

3.06 EXPANSION JOINT INSTALLATION

A. General: Install expansion joints where indicated, and elsewhere as determined by Installer 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.

3.07 EXPANSION LOOP INSTALLATION

A. General: Fabricate expansion loops as indicated, in locations indicated, and elsewhere as determined by Installer 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 indicated, and elsewhere as determined by Installer to properly anchor piping in relationship to expansion loops.

3.08 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 per local code. 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. Installation of Building Attachments:

1. Install building attachments at required locations within concrete or on structural steel for proper piping support. Space attachments within maximum piping span length indicated in MSS SP-69 Table 3 or local code, whichever is more stringent. Install additional hangers at 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 is indicated, install reinforcing bars through openings at top of inserts.

C. 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.

D. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods, or by plastic coated hangers.

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.
2. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.
3. 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.

F. 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. **Saddle and Shield** Installation:

   a. 3” and smaller piping: Contractor option; **protection shields or thermal hanger shields**. Provide on cold/chilled water a vapor barrier.
   b. 4” and Larger: Contractors option; **thermal hanger shields or protection saddles**. Provide on cold/chilled water piping a vapor barrier.

G. Support of pipe, tubing and equipment shall be accomplished by means of engineered products, specific to each application. Makeshift, field devised methods shall not be allowed.

H. Hangers, struts and hardware in outdoor or high humidity areas including but not limited to; Natatoriums, pool locker rooms, pool chemical rooms and pool equipment rooms, shall be field painted by the general contractor. Coordinate hanger material with painting contractor prior to painting. The installing paint contractor shall provide preparation and painting suitable for the material used.

3.09 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 principal 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.

3.10 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 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 boiler and chiller.
3. At inlet and outlet of each hydronic coil in air handling units, and built-up central systems.
4. At inlet and outlet of each hydronic heat exchanger.
5. At inlet and outlet of each hydronic heat recovery unit.

C. Thermometer Wells: Install in piping tee where indicated, in vertical upright position. Fill well with oil or graphite, secure cap.

D. Temperature Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.

3.11 INSTALLATION OF PRESSURE AND TEMPERATURE TEST PLUGS

A. General: Install in piping where indicated, located on pipe at the most readable position. Secure cap.

B. For horizontal pipe, install in top half of pipe line.

3.12 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 water cooled condensers and refrigerant cooled chillers.

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.

3.13 CLEANING, FLUSHING, INSPECTING

A. General: Clean exterior surfaces of superfluous materials, and prepare for application of specified coatings (if any). Flush out 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. Provide a pre-start up liquid alkaline dispersant cleaner for all the flushing and cleaning of all HVAC water systems.

3.14 PIPING TESTS

A. Test pressure piping in accordance with ASME B31.

B. General: Provide temporary equipment for testing, including pump and gauges. 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. Air may be used if allowed by Code. Air cannot be used for plastic piping.

1. Required test period is 8 hours.
2. Test each piping system at 150% of operating pressure indicated, but not less than 100 psi test pressure.
3. Test force drainage (pumped) piping at 50 psi.
4. Observe each test section for leakage at end of test period. Test fails if leakage is observed or if pressure drop exceeds 5% of test pressure.

C. 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.

D. Drain test water from piping systems after testing and repair work has been completed.

END OF SECTION 232000

SECTION 232100 - HVAC HYDRONIC SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Refer to Section 232000: HVAC Pipes, Valves and Piping Specialties.

1.02 DESCRIPTION OF WORK

A. Types of equipment specified in this section include the following:

1. Hydronic Piping and Specialties.
2. HVAC Pumps.
3. Unit Heaters.
4. Cabinet Unit Heaters.
5. Condensate Pump.
6. Pre-Startup Cleaning of HVAC Piping Systems.
7. Chemical System Water Treatment.
8. Closed System Water Treatment.

PART 2 - PRODUCTS

2.01 BASIC PIPES AND PIPE FITTINGS

A. General: Provide piping materials and factory-fabricated piping specialties of sizes, types, pressure ratings, temperature ratings, and capacities as indicated. 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. Provide pipes and pipe fittings complying with Division 23, Section 232000.

2.02 MOTORS AND VARIABLE FREQUENCY DRIVES

A. For products contained in this section requiring motors and variable frequency drives, motors and frequency drives shall comply with the requirements of Division 23, Section 232000.

2.03 BASIC VALVES

A. General: Provide valves complying with Section 232000 and in accordance with the following listing:

B. Shutoff Valves:

1. 3" and smaller: Ball valves.
2. 4" and larger: Butterfly valves only.

C. Drain Valves:

1. 3" and smaller: Ball valves.
2. 4" and larger: Butterfly valves only.

D. Check Valves:

1. Refer to “Part 3 – Execution” section of this Specification section for check valve requirements.

E. Balance Valves:

1. 2" and smaller: Venturi type.
2. 2" and smaller: Variable CV/Orifice type.
3. 2-1/2" and larger: Plug or ball eccentric type valve upstream of flow measuring station or as indicated on drawings. See Section 232000 for flow measuring station.

F. Acceptable Manufacturers: Refer to Division 23, Section 232000.

2.04 AIR VENT VALVES

A. Manual Air Vent Valves: Provide manual vent valves designed to be operated manually with screwdriver or thumbscrew, 1/8" NPS connection.

B. Automatic Air Vent Valves: Provide automatic vent valves designed to vent automatically with float principle, stainless steel float and mechanisms, cast-iron body, pressure rated for 125 psi, ½" or ¾” NPS inlet and outlet connections.

C. Acceptable Manufacturers:

1. Armstrong
2. Bell & Gossett ITT.
3. Hoffman Specialty ITT.
4. Spirax Sarco.
5. Taco, Inc.
6. Thrush.

2.05 MICRO-BUBBLE AIR ELIMINATOR AND DIRT SEPARATOR

A. General: Provide air and dirt separation fittings as indicated.

1. All fittings shall be fabricated steel, rated for 150 psig design pressure and be selected for less than 1 foot of water pressure drop and velocity not to exceed 4 feet per secton through the unit at specified GPM.
2. Units to include internal copper coalescing medium to facilitate maximum air and dirt separation and suppress turbulence.
3. Provide integral high capacity float actuated air vent at top fitting of tank.

4. Units shall have bottom blowdown connection.
5. Air Eliminators shall be capable of removing 100% of the free air, 100% of the entrained air, and up to 99.6% of the dissolved air in the system fluid.
6. Units shall have the bottom of the vessel extended for dirt separation with the system connection nozzles equidistant from the top and bottom of the vessel and include a blowdown tank connection and valve.
7. Dirt separation shall be at least 80% of all particles 30 micron and larger within 100 passes.

B. Acceptable Manufacturers:

1. Spirotherm.
2. Prior Approved Equal.

2.06 EXPANSION TANKS

A. General: Provide diaphragm or bladder-type expansion tanks of size and number as indicated. Construct tank of welded steel, constructed, tested, and stamped in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code for working pressure of 125 psi and temperature rating of 240°F. Furnish National Board Form U-1 denoting ASME certification. Provide specially compounded heavy duty butyl flexible diaphragm or bladder securely sealed into tank to permanently separate air charge from system water, and to maintain design expansion capacity. Provide pressure gauge, air-charging fitting, and drain fitting.

B. Acceptable Manufacturers:

1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett ITT.
4. Taco, Inc..
5. Thrush Co., Inc.
6. Wessels

2.07 PRESSURE RELIEF VALVES

A. General: Provide pressure 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.

B. Combined Pressure-Temperature Relief Valves: Bronze or iron body, test lever, thermostat, complying with ANSI Z21.22 listing requirements for temperature discharge capacity. Provide temperature relief at 210°F (99°C), and pressure relief at 125 psi.

C. Pressure Relief Valves: Bronze body, test lever, ASME rated. Provide pressure relief as stated on drawings.

D. Acceptable Manufacturers:

1. Amtrol, Inc.
2. Bell & Gossett ITT.

3. Spirax Sarco.
4. Watts Regulator Co.

2.08 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 is listed in pump schedule. Provide pumps of same type by same manufacturer.

B. In-line Wet Rotor Circulator Pumps:

1. General: Provide in-line circulator pumps where indicated, and of capacities as scheduled.
2. Type: Horizontal mount, radially split case, oil-lubricated, designed for 125 psi working pressure, and 225°F continuous water temperature.
3. Body: Cast iron, with suction and discharge gage tappings.
4. Shaft: Hardened alloy steel.
5. Bearings: Oil-lubricated bronze journal bearings.
6. Seal: Mechanical, with carbon seal ring and ceramic seat.
7. Motor: Non-overloading at any point on pump curve, open, drip- proof, oil-lubricated journal bearings, resilient mounted construction, built-in thermal overload protection on single phase motors. Refer to motor specification 230010 for additional requirements.
8. Provide dual arm pump with (1) inlet and out piping connection and (2) impellors and (2) motors for redundancy where indicated on the mechanical schedules.
9. Coupling: Self-aligning, flexible coupling.
10. Impeller: Enclosed type, hydraulically and dynamically balanced, and keyed to shaft.
11. Acceptable Manufacturers:

    a. Grundfos
    b. Prior Approved Wet Rotor

2.09 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 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. Coils: Construct of plate-type aluminum fins, mechanically bonded to copper tubes. Design coil for use in steam or hot water applications.

D. Motors: Provide totally enclosed motors, with built-in overload protection, having electrical characteristics as scheduled.

E. Accessories: Provide the following accessories:

1. Mounting Bracket.
2. Provide unit mounted disconnect switch.

F. Acceptable Manufacturers:

1. Airtherm Mfg. Co.
2. Daikin Manufacturing Co.
3. Sterling Hydronics.
4. Trane (The) Co.
5. Vulcan Radiator Co.
6. Zehnder Rittling.

2.10 CABINET UNIT 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, filter, and insulation.

B. Chassis: Galvanized steel wrap-around structural frame with edges flanged.

C. Insulation: Faced, heavy density glass fiber.

D. Cabinet: Manufacturer’s standard gauge removable front panel, 18-gauge top and side panels. Insulate front panel over entire coil section. Provide locking access door on coil connection side. Clean cabinet parts, bonderize, phosphatize, and flow-coat with baked-on primer. White finish on white ceilings. Color as selected by Architect/Engineer from manufacturer’s standard color chart.

E. Water Coils: Construct of 5/8" seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 300 psi and leak test at 300 psi under water. Provide same end connections for supply and return.

F. Steam Coils: Construct of 1" seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 75 psi and leak test at 450 psi 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 galvanized steel.

H. Motors: Provide electronically commutated high-efficiency, programmable brushless DC motor resiliently mounted on motor board. Shaded pole motors are not acceptable. Single speed motors are not acceptable.

I. Filters: Provide 1" thick throwaway type filters in fiberboard frames.

J. Accessories: Provide the following accessories as indicated and/ or scheduled:

1. Hinged access door for accessing unit in an above ceiling installation.

2. Hinged access door with integral stamped return/supply grilles a recessed ceiling installation.
3. Removable access door for accessing unit in an above ceiling installation where there is not sufficient space for a hinged access door.
4. Wall Boxes: Provide aluminum wall boxes with integral eliminators and insect screen.
5. Recessing Flanges: Provide 18-gauge steel flanges for recessing cabinet heaters into wall or ceiling.
6. Duct Collars: Provide duct collars where specified.
7. Sub-bases: Provide 18-gauge steel sub-base for vertical units, height as indicated.
8. Extended Oilers: Provide plastic motor oiler tubes extending to beneath top discharge grille.
9. Provide unit mounted disconnect switch.

K. Acceptable Manufacturers:

1. Airtherm Mfg. Co.
2. Daikin Manufacturing Co.
3. Sterling Hydronics.
4. Trane (The) Co.
5. Vulcan Radiator Co.
6. Zehnder Rittling.

2.11 CONDENSATE PUMP

A. Provide condensate pumps for removal of condensate where required for condensate lift from air conditioning equipment and as indicated on the drawings.

B. Condensate pumps at a minimum shall include the following features. Increase capacities as required for equipment served but size no smaller than below.

1. 1/50 hp high performance motor.
2. ABS condensate reservoir tank, motor cover and volute.
3. Integral condensate reservoir tank (minimum).
4. Stainless seal pump shaft.
5. Snap action float switch.
6. Integral check valve.
7. Three inlet drain holes.
8. Thermal overload protection.
9. Overflow / pump failure switch.
10. Plenum rated for ceiling application.
11. 120/1 power, hard wired for above ceiling applications, 3-conductor cable with grounded 3-prong plug for floor mounted or exposed applications.

C. Acceptable Manufacturers

1. Little Giant Model VCC-20-P (above ceiling applications) Model VCC-20 (floor mounted or exposed applications)
2. Liberty

2.12 PRE-STARTUP CLEANER

A. Provide a pre-startup liquid alkaline dispersant cleaner for the flushing and cleaning of all HVAC water systems to remove oil and foreign matter from the piping and equipment prior to the final filling of the systems. This chemical shall not be injurious to persons, piping, pipe joint compounds, packings, coils, valves, pumps, and their mechanical seals, tubes or other parts of the system.

B. Furnish complete instruction dictating the quantities of the cleaner to use, methods, and durations of the operation.

2.13 BYPASS CHEMICAL POT FEEDERS

A. General: Provide where indicated or otherwise necessary, bypass feeders of size and capacity noted on the drawings.

B. Provide a bypass feeder for adding chemical to the closed water system. The feed shall have (2) 3/4" NPT, female pipe connections, a 3/4" NPT female drain pipe connection, and a 3 1/2" top opening cap, with an "O" ring seat. The feeder shall have a continuous threaded closure requiring 2 1/2 turns to close and seal. Capacity of the feeder shall be **2 OR 5** gallons, capable of operating at 200 psig and at a temperature up to 200°F. **Provide feeder with a built in support and mounting for cartridge filter or replaceable 5 micron cloth filter with integral metal basket.**

C. The by-pass feeder shall be provided with mounting legs to elevate the feeder off the floor. The legs shall have holes to allow mounting by anchor bolts.

D. Acceptable Manufacturers:

1. A&F Machine.
2. Neptune.
3. Sage Equipment Co.
4. Vector.
5. Wingert.

2.14 CLOSED SYSTEM WATER TREATMENT CHEMICALS

A. Supply water for chilled water and boiler systems shall be treated by a professional water treatment specialist who is familiar with the operating conditions and materials of construction specified for the equipment and associated piping. Provide closed system chemical treatment chemicals including a pH buffer, oxygen scavenger, and corrosion inhibiting surfactant.

PART 3 - EXECUTION

3.01 INSPECTION

A. General: Examine areas and conditions under which hydronic systems materials and products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to the installer.

3.02 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.

3.03 INSTALLATION OF HYDRONIC PIPING

A. Install eccentric reducers where pipe is reduced in size in direction of flow, with tops of both pipes and reducer flush.

B. Install piping level with no pitch.

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.

E. Copper piping joints shall have pipe cut square, and reamed with burrs removed. Clean with medium grit emory cloth, flux pipe and fitting with nokorode paste. Use only 95-5 solder.

F. Refer to Section 232000 for hanger and support requirements.

G. Refer to Section 232000 for provisions for movement in hydronic piping.

3.04 INSTALLATION OF VALVES

A. Shutoff Valves: Install on inlet and outlet of each mechanical equipment item, on branch lines serving three or more terminal units, and elsewhere as indicated.

B. Drain Valves: Install on each mechanical 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 hydronic piping system.

C. Install wafer checks on all pump applications (in-line pumps, base mounted pumps, pumped coils). Install swing check valves for all other applications. All swing check valves shall be installed in the horizontal position. Vertical installation is not acceptable.

D. Balance Valves: Install balance valve on outlet of each hydronic terminal, on end of each hydronic zone circuit, on discharge of each hydronic pump, on branch return lines serving three of more terminal units, and elsewhere as indicated. After hydronic system balancing has been completed, permanently mark final balanced position with memory stop or yellow lacquer across body.

3.05 INSTALLATION OF HYDRONIC SPECIALTIES

A. Balancing Devices:

1. Balancing devices to all hydronic terminals shall be furnished and installed so that the flow to each device can be read and adjusted by the Test and Balance contractor. This includes but is not limited to the following:

   a. Install P&T test plugs on the inlet and outlet to every hydronic terminal device, whether or not shown. This shall include chillers, boilers, heat exchangers, coils, pumps, heaters, etc.
   b. Install flow measuring/balancing devices (circuit setters or venturis with balance valves) at each hydronic device, whether or not shown, so that flow rates can be read, adjusted and set.

B. Vent Valves:

1. Manual Vent Valves: Install manual vent valves 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.
2. Install a full size air chamber and pipe down with 1/4" copper tubing to a petcock or key vent. If the vent is above ceiling, install the petcock 6" above the ceiling. Provide manual air vent fittings on all hydronic coils. Extend air vents to workable levels in gymnasium.
3. Automatic Vent Valves: Install automatic vent valves 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. Diverting Fittings: Install diverting fittings as indicated and in accordance with manufacturer's instructions. Position fittings on supply and return mains with proper orientation for flow.

D. Air Separators:

1. Install external micro-bubble eliminator and dirt separator on the pump suction line in the locations as shown in the installation instructions. Connect inlet and outlet piping. Install shut-off valve on air eliminator drain connection and extend drain piping to floor drain.

E. Diaphragm-Type Expansion Tanks: Install diaphragm-type expansion tanks on floor as indicated, in accordance with manufacturer's instructions. Suspend horizontal tanks from

building structure with all threaded rods and trapeze support channels. Vent and purge air from hydronic system, charge tank with proper air charge as recommended by manufacturer. Install isolation valve and drain valve on system piping connection.

F. Bladder-Type Expansion Tanks: Install bladder-type expansion tanks on floor as indicated, in accordance with manufacturer's instructions. Vent and purge air from hydronic system, charge tank with proper air charge as recommended by manufacturer. Install isolation valve and drain valve on system piping connection.

G. Bypass Pot Feeders: Install bypass pot feeders on each hydronic system at pump discharge or elsewhere, as indicated. Install in upright position with top of pot not more than 48" above floor. Connect pot feeder to pump discharge with unions and ball valves. Provide sight glass on inlet of pot feeder. Install shut-off valve in pump discharge line between connections to the pot feeder. Provide drain with ball shut-off valve and a hose end connection.

H. Pressure Relief Valves: Install for each hot water boiler or heat exchanger as indicated, and in accordance with manufacturer's installation instructions. Pipe discharge to floor drain.

I. Control Components: Furnish and install flow switches, flow sensors, thermowells and pressure/temperature taps in accordance with the manufacturer’s recommendations. Install control valves furnished by the temperature controls contractor.

3.06 INSTALLATION OF PUMPS

A. General: Install HVAC pumps where indicated, in accordance with manufacturer's published installation instructions, complying with recognized industry practices to ensure that HVAC pumps comply with requirements and serve intended purposes.

B. Access: Provide access space around HVAC pumps for service as indicated, but in no case less than that recommended by manufacturer.

C. Mounting:

1. Install in-line pumps, supported from piping system, wall or structure above.

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. 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.

F. Start-Up: Lubricate pumps before start-up. Start-up in accordance with manufacturer's instructions.

3.07 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.

3.08 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.

3.09 INSTALLATION OF CONDENSATE PUMPS

A. Provide pumps on indoor air conditioning equipment where required for condensate removal lift and as specified on the drawings.

B. Pipe condensate pump discharge from pump outlet vertically as high as possible then offset piping to gravity drain. Piping from pump shall be minimum 3/4” copper piping, provide maximum 1’-0” of factory provided 3/8” poly tubing from pump outlet then transition to 3/4” copper drain piping. Poly tubing shall be installed free of any kinks or drops that would create a water “trap”.

C. Piping from air conditioning unit drain pan to condensate pump shall be minimum 3/4” copper piping.

D. Where required for wall mounted units provide wall support for mounting of condensate pump against wall below the wall mounted indoor unit.

E. Wire condensate pump factory safety switch to indoor air conditioning equipment. Switch shall shut off associated equipment upon pump failure or condensate overflow.

3.10 CLOSED LOOP SYSTEM FILLING AND CHEMICAL TREATMENT START-UP.

A. The chemical treatment specialist shall be responsible for start-up of closed loop treatment system, shall add necessary chemicals and shall make adjustments necessary for proper treatment.

B. The Division 23 contractor shall coordinate scheduling of system filling / air purge with the chemical treatment start-up. Chemical treatment for closed loop systems shall be provided no longer than 24 hours after the system has been filled with water.

C. The chemical treatment specialist shall provide a written report to the Division 23 Contractor indicating that the start-up has been completed. Report shall include measured system volumes, quantities of closed loop chemicals that were added and the following measurements / observations at a minimum; Color and Appearance, System pH, Total Dissolved Solids (TDS), Hardness as CaCO3, Alkalinity as Ca CO3, Chlorides, Sulfates and Phosphate.

D. Fill water for the system shall be connected upstream of the water softener. Do not fill systems with softened water.

E. When filling the system measure and record the volume of fill water used and provided necessary closed loop chemical treatment, including at a minimum a pH buffer, oxygen scavenger, and corrosion inhibiting surfactant to meet the concentration control as recommended by the chemical treatment specialist.

F. Parameters for minimum concentration control requirements are as follows. Chemicals used should be should be verified to be compatible with the associated materials used in the submitted equipment and with associated piping materials. Review equipment installation manuals and enhance requirements below if necessary to comply.

1. pH Greater than 7 and less than 8
2. Total Dissolved Solids (TDS) Less than 900 ppm
3. Hardness as CaCO3 30 to 500 ppm
4. Alkalinity as CaCO3 30 to 500 ppm
5. Chlorides Less than 50 ppm
6. Sulfates Less than 75 ppm.
7. Phosphate 2,000 to 3,000 ppm.

3.11 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.

C. Install new filter units for terminals requiring same.

3.12 SPARE PARTS

A. Furnish to Owner, with receipt, one spare set of belts for each type of belt driven centrifugal fan.

B. Furnish to Owner, with receipt, one set of air filters for each type of unit requiring air filters.

C. Furnish to Owner, with receipt, three spare sets of filters for each bypass filter feeder provided with the project.

3.13 OPERATOR TRAINING AND SERVICE

A. The Water Treatment Supplier shall instruct the Owner's operating personnel so as to familiarize them with all treatment equipment and procedures per Maintenance Service specified in Part 1 of this Section.

END OF SECTION 232100

SECTION 232300 - REFRIGERANT PIPING SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Refer to Section 232000: HVAC Pipes, Valves and Piping Specialties.

1.02 DESCRIPTION OF WORK

A. Types of equipment specified within this section include the following:

1. Ductless Split System.

1.03 SUBMITTALS

A. Shop Drawings: Submit manufacturer approved and signed 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.

1.04 REGULATIONS

A. Refrigeration systems or appliances shall:

1. Be equipped with a fully protected and isolatable receiver or condenser of sufficient capacity to hold the complete refrigerant charge during servicing or repairs. This requirement shall apply only to systems and appliances with 50 pounds or greater of the manufacturer's recommended/estimated charge. However, refrigeration systems with less than 50 pounds capacity shall be equipped with suitable access valve(s) in order to provide for recovery of refrigerant charge if necessary.
2. Be equipped with a system of relief valves, including reseatable relief valve and non-fragmenting disk, designed to automatically reseat after activation, to minimize refrigerant losses in the case of equipment breakdown or failure.
3. Be installed meeting, at a minimum, the applicable requirements set forth in the ASHRAE Guideline 15-2007.

PART 2 - PRODUCTS

2.01 MATERIALS AND PRODUCTS

A. General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, temperature ratings, and capacities as indicated. Provide materials and products complying with ANSI 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.

2.02 BASIC PIPES AND PIPE FITTINGS

A. General: Provide pipes and pipe fittings complying with Division 23, Section 232000.

2.03 SPECIAL REFRIGERANT VALVES

A. General: Special valves required for refrigerant piping include the following types:

B. Globe and Check Valves:

1. Globe Shutoff Valves: Forged brass, packed, back seating, winged seal cap, 300°F (149°C) temperature rating, 500 psi working pressure.
2. 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 working pressure.
3. Acceptable Manufacturers:

    a. Henry Valve Co.
    b. Sporlan Valve Co.

C. Solenoid Valves:

1. 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" conduit adapter, 250°F (121°C) temperature rating, 400 psi working pressure.
2. Manual Operator: Provide manual operator to open valve.
3. Acceptable Manufacturers:

    a. Alco Controls Div.; Emerson Electric Co.
    b. Automatic Switch Co.
    c. Sporlan Valve Co.

D. Thermal Expansion Valves: Shall be sized and selected per equipment manufacturers recommendation.

1. Acceptable Manufacturers:

    a. Alco Controls Div.
    b. Henry Valve Co.
    c. Sporlan Valve Co.

2.04 REFRIGERANT SPECIALTIES

A. Refrigerant Strainers: Brass shell and end connections, brazed joints, monel screen, 100 mesh, UL-listed, 350 psi working pressure.

B. Moisture-Liquid Indicators: Forged brass, single port, removable cap, polished optical glass, solder connections, UL-listed, 200°F (93°C) temperature rating, 500 psi working pressure.

C. Refrigerant Filter-Driers: Steel shell, ceramic fired desiccant core, solder connections, UL-listed, 500 psi 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 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.

G. Acceptable Manufacturers:

1. Alco Controls Div.; Emerson Electric Co.
2. Henry Valve Co.
3. Sporlan Valve Co.

2.05 SPLIT SYSTEM AIR CONDITIONING UNITS

A. General:

1. Furnish & install a Ductless, Split System Air Conditioner, consisting of an indoor, high wall mounted evaporator/blower section & matching outdoor condensing section.
2. System shall bear the ARI label showing that the system is ARI certified.
3. System shall meet or exceed the minimum, Seasonal Energy Efficiency Rating (SEER) of 13 as certified by the ARI testing programs.
4. System indoor & outdoor units shall operate at sound levels equal to or below the specified system.
5. Installation & Owners Manuals shall be provided with each system.
6. Matching indoor & outdoor sections shall be connected by deoxidized, annealed refrigerant copper tubing, type “L”, cleaned & capped. All systems shall have flared refrigeration connections on both indoor & outdoor sections. Size & insulate tubing according to manufacturer’s specifications.
7. System indoor & outdoor sections shall be completely factory assembled & wired, with a precharge of refrigerant.
8. A single power source shall provide voltage to both the outdoor & indoor units.
9. Electrical wire & connections to outdoor section, and between indoor & outdoor section, shall be sized, installed & grounded by the installer in conformance with the National Electrical Code (N.E.C.), local codes, as well as, manufacturer’s instructions.

10. System shall be equipped with a microprocessor control system.
11. System shall include the following:

    a. High efficiency, rotary compressor.
    b. Cap tube refrigerant control.
    c. Indoor coil freeze protection.
    d. Built-in auto restart after power failure.
    e. Short cycle time delay.
    f. Automatic indoor fan speed determined by the system microprocessor.
    g. Dehumidification mode.
    h. Washable anti-mold poly filters.
    i. Indoor mounted operation selector & lamp showing operation, standby & timer modes, with start up test mode & manual on/off switch.

B. Outdoor Condensing Section

1. Outdoor condensing section shall be factory assembled, wired, piped & pre-charged with a start up amount of R-410A refrigerant.
2. Unit shall be constructed of G90 galvannealed steel with corrosion inhibiting, powder coated paint.
3. Unit shall be furnished with a high efficiency, scroll compressor with internal overload protection, securely mounted with vibration isolators to reduce noise & vibration.
4. Condenser coil heat exchanger shall be constructed of nonferrous, rifled copper tubing with enhanced aluminum slit fins mechanically bonded to the copper.
5. A suction line accumulator, a coil temperature sensor and cap tube metering device shall be factory installed.
6. Fan motor shall be direct drive with internal overload protection, permanent lubrication, with propeller type fans, mounted for horizontal air discharge.
7. Brass valves with refrigeration flare connections & flare nuts, & service ports shall be factory mounted, externally for easy access.
8. The unit shall be test started by the manufacturer at their factory prior to shipment for installation.
9. Low Ambient Controls:

    a. Outdoor unit shall contain a printed circuit board with a sequencer, factory mounted & wired, to assist in control of low ambient operation.
    b. Unit shall be able to operate in the A/C mode down to -10 degrees Fahrenheit outdoor temperature.

C. Indoor Evaporator Section

1. Indoor section(s) shall be high wall mount type, factory assembled & wired.
2. Wall mounting fixture, plate & mounting diagram shall be included with each system, as well as wall sleeves to protect wall where tubing passes through.
3. Unit shall contain an evaporator coil heat exchanger constructed of nonferrous, rifled copper tubing with enhanced aluminum slit fins, mechanically bonded to the copper.
4. A single cross-flow blower wheel, statically & dynamically balanced shall be attached to a single direct drive, PSC fan motor, with overload protection, permanent lubrication & multi-speed capability.

5. Unit shall contain a Printed Circuit Board (PCB) with a control circuit fuse & microprocessor, factory wired & mounted, that receives & processes all commands & transmissions from the system Controller.
6. Indoor unit shall contain an Operation Switch with visible lamps for operation, standby & timer functions, as well as, a system test switch & a manual ON/OFF switch.
7. Unit shall contain a room sensor thermistor, a coil temperature safety thermistor to prevent freeze-up in the A/C mode, a factory installed condensate drain pan, drain hose & fitting, and refrigeration line connections with flare nuts.
8. Unit shall contain knockouts on both sides of the casing that allow refrigerant lines to be brought to the unit from multiple directions.
9. A motorized louver/flap, controlled by the unit controller, shall provide automatic, full oscillating supply airflow, as well as being capable of being placed in a set, stationary position.
10. Unit shall also contain adjustable, horizontal air louvers to provide user defined, directional airflow.
11. Unit shall be provided with anti-mold, poly type washable air filters that can be easily removed without removing indoor unit casing.
12. Indoor unit shall be powered by voltage from the matching outdoor unit.

D. Unit Accessories:

1. Provide the following accessories with the split system unit:
2. Insulated Copper Line Set
3. Condensate Pump
4. Hail Guards: Provide manufacturer's coil guard for condenser coil protection.

E. Acceptable Manufacturers:

1. Sanyo.
2. Mitsubishi.
3. Daikin.

2.06 CONDENSATE PUMP

A. Provide condensate pumps for removal of condensate where required for condensate lift from air conditioning equipment and as indicated on the drawings.

B. Condensate pumps at a minimum shall include the following features. Increase capacities as required for equipment served but size no smaller than below.

1. 1/50 hp high performance motor.
2. ABS condensate reservoir tank, motor cover and volute.
3. Integral condensate reservoir tank (minimum).
4. Stainless seal pump shaft.
5. Snap action float switch.
6. Integral check valve.
7. Three inlet drain holes.
8. Thermal overload protection.
9. Overflow / pump failure switch.
10. Plenum rated for ceiling application.

11. 120/1 power, hard wired for above ceiling applications, 3-conductor cable with grounded 3-prong plug for floor mounted or exposed applications.

C. Acceptable Manufacturers

1. Little Giant Model VCC-20-P (above ceiling applications) Model VCC-20 (floor mounted or exposed applications)
2. Liberty

PART 3 - EXECUTION

3.01 INSPECTION

A. General: Examine areas and conditions under which refrigerant systems and products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF REFRIGERANT PIPING

A. Install refrigerant piping with 1/4" per foot (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.

B. 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.

C. Bleed dry nitrogen through refrigerant piping during brazing operations.

D. Refer to Section 232000 for Hanger and Support requirements.

3.03 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.

3.04 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.

3.05 EQUIPMENT CONNECTION

A. General: Connect refrigerant piping to mechanical equipment as indicated, and comply with equipment manufacturer's instructions where not otherwise indicated.

3.06 FIELD QUALITY CONTROL

A. Refrigerant Piping Leak Test: Prior to initial operation, clean and test refrigerant piping in accordance with ANSI B31.5, "Refrigeration Piping". Perform first test with dry nitrogen, using soap solution to test all joints. Perform second test as follows: fill system with 20 psi refrigerant and then charge to **200 psi (R-22) / 480 psi (R-410A)** with nitrogen. Let stand 24 hours and check to see that the charge has held. Check all joints with a halide leak detector. Perform final test by pulling a 2 mm Hg vacuum. The system must hold this vacuum for a period of 24 hours. System must be entirely leak-free.

B. Repair or replace refrigerant piping as required to eliminate leaks, and retest as specified to demonstrate compliance.

3.07 INSTALLATION OF SPLIT SYSTEM AIR CONDITIONING UNITS

A. General: Install split system air conditioning units where indicated, in accordance with equipment manufacturer's published installation instructions, and with recognized industry practices, to ensure that units comply with requirements and serve intended purposes.

B. Support: Install roof-mounted split system air conditioning unit as indicated on drawings. Coordinate setting and support of unit with General Contractor prior to installation.

C. 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.

D. Distance between indoor & outdoor unit(s) shall not exceed manufacturer’s specifications.

E. Refrigerant tubing size shall not vary from manufacturer’s specifications, and shall be properly secured & insulated.

F. Installer shall insulate both liquid & suction lines individually.

G. Outdoor condenser shall be mounted & secured to accommodate for extreme weather conditions.

H. System shall be mounted & placed as shown on plans within all minimum clearances as specified by manufacturer's instructions, & secured to provide for safe operation.

3.08 INSTALLATION OF CONDENSATE PUMPS

A. Provide pumps on indoor air conditioning equipment where required for condensate removal lift and as specified on the drawings.

B. Pipe condensate pump discharge from pump outlet vertically as high as possible then offset piping to gravity drain. Piping from pump shall be minimum 3/4" copper piping, provide maximum 1'-0" of factory provided 3/8" poly tubing from pump outlet then transition to 3/4" copper drain piping. Poly tubing shall be installed free of any kinks or drops that would create a water "trap".

C. Piping from air conditioning unit drain pan to condensate pump shall be minimum 3/4" copper piping.

D. Where required for wall mounted units provide wall support for mounting of condensate pump against wall below the wall mounted indoor unit.

E. Wire condensate pump factory safety switch to indoor air conditioning equipment. Switch shall shut off associated equipment upon pump failure or condensate overflow.

3.09 FIELD QUALITY CONTROL

A. Testing: Upon completion of installation of split system air conditioning units, start-up and operate equipment to demonstrate capability and compliance with requirements. Field correct malfunctioning units, then retest to demonstrate compliance.

3.10 EXTRA STOCK

A. Provide one complete extra set of filters for each split system air conditioning units. Install new filters at completion of split system air conditioning unit work, and prior to testing, adjusting, and balancing work. Obtain receipt from Owner that new filters have been installed.

END OF SECTION 232300

SECTION 233000 - AIR DISTRIBUTION

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Types of equipment specified in this section include the following:

1. Metal Ductwork.
2. Ductwork Accessories.
3. Grilles, Registers & Diffusers.
4. Louvers and Dampers.
5. Fans.
6. Variable Air Volume Terminals.
7. Flues.
8. Range Hood.
9. Sound Attenuators.

1.02 SUBMITTALS

A. Submit scaled layout drawings of metal ductwork and fittings including, but not limited to, duct sizes, locations, elevations, access doors and slopes of horizontal runs, wall and floor penetrations, and connections. Show interface and spatial relationship between ductwork and proximate equipment. 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.

B. Within 30 days after award of contract, submit a shop drawing for approval to the structural engineer showing size and location of all openings through roofs and structural members. Do not proceed until the shop drawing has been reviewed, approved and returned.

C. Contractor shall submit sizing and routing diagrams and calculations for all venting systems for the engineer's approval. A venting system shall include: flue pipe/duct, combustion air pipe/duct and all accessories including terminations. These diagrams and sizing calculations shall be provided by the vent manufacturer and/or venting system installer. Before submitting to the engineer, the diagrams and calculations shall be approved by the manufacturer of the appliance being vented. This submittal requirement applies to all vented appliances including but not limited to **boilers,** and water heaters and shall have an approval letter from the manufacturer attached.

1.03 TEST AND BALANCE COORDINATION

A. Prior to starting work, the contract documents shall be given to the Test and Balance contractor for his review. If there are any areas of the air distribution system that cannot be balanced, due to the configuration of the system, a Request for Clarification shall be made in a timely manner to allow revisions to the documents before the systems are installed.

PART 2 - PRODUCTS

2.01 DUCTWORK

A. Material:

1. Galvanized Sheet Metal: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel CS-B, lockforming quality; with G 90 zinc coating in accordance with ASTM A 653; and mill phosphatized for exposed locations.
2. Stainless Steel Sheet: Where indicated, provide stainless steel complying with ASTM A 167; Type 302, 304, or 316; with No. 4 finish where exposed to view in occupied spaces, No. 1 finish elsewhere. Protect finished surfaces with mill-applied adhesive protective paper, maintained through fabrication and installation.
3. Aluminum sheet: Where indicated, provide aluminum sheet complying with ASTM B 209, Alloy 3003, Temper H14. Provide mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts. Reinforcing angles, bars, tie rods, and other structural members shall be alloy 6061-T6. Hangers shall be 6061-T6 aluminum or galvanized or painted steel with a dielectric isolation pad between the dissimilar metals.
4. Carbon steel: Where indicated, provide ungalvanized carbon steel, lockforming grade, hot rolled steel conforming to ASTM A366 or A619.

B. Rectangular Duct:

1. Construct rectangular ductwork to meet all functional criteria defined in Section 11, of the SMACNA "HVAC Duct Construction Standards Metal and Flexible" 2005 Edition. All ductwork must comply with all local, state and federal code requirements.
2. Where the standard allows the choice of external reinforcing or internal tie rods, only the external reinforcing options shall be used.
3. Pittsburgh lock shall be used on all longitudinal seams. All longitudinal seams will be sealed with mastic sealant. Snaplock is not acceptable.
4. Ductmate or W.D.C.I. proprietary duct connection systems will be accepted. Duct constructed using these systems will refer to the manufacturers guidelines for sheet gauge, intermediate reinforcement size and spacing, and joint reinforcements.
5. Formed on flanges (T.D.C./T.D.F./T-25A/T-25B) shall be constructed as SMACNA T-25 flanges, whose limits are defined on Page 2.76 2005 SMACNA Manual, Third Edition. No other construction pertaining to formed on flanges, will be accepted. Formed on flanges shall be accepted for use on ductwork 42" wide or less, 2" static (positive) or less and must include the use of corners, bolts and cleat.
6. Ductmate type systems that use a butyl Rubber Gasket which meets Mil-C 18969B, Type II Class B, TT-C-1796 A, Type II Class B, and TTS-S-001657 must also pass UL-723. This material, in addition to the above, shall not contain vegetable oils, fish oils, or any other type vehicle that will support fungal and/or bacterial growth (as defined in 21CFR 177, 1210 closures with sealing gaskets for food containers).
7. Aluminum duct shall be fabricated using the aluminum thickness equivalence table in the standard. Simply increasing the thickness by two gauges is not acceptable.
8. Fittings shall be constructed and reinforced as ductwork according to the longest span.

C. Round and Flat-Oval Duct:

1. Round and oval duct shall be galvanized steel, constructed in accordance with Section 11 of the 2005 SMACNA “Duct Construction Standards, Metal and Flexible”, except as noted.
2. Minimum duct gauge shall be 26 gauge.
3. Snaplock Ductwork with self-locking, pre-sealed longitudinal seams. Ductwork shall incorporate a factory applied gasket in the longitudinal seam and female ends at transverse joints. Gauges shall be in accordance with SMACNA Duct Construction Standard and fittings in accordance with SMACNA Duct Construction Standard:

    a. Duct Sizes: up to 12” diameter. Application limited to low-pressure, concealed locations only.

4. Spiral Round Ductwork: Gauges shall be in accordance with SMACNA Duct Construction Standard and fittings in accordance with SMACNA Duct Construction Standard, except as noted:

    a. Joints 0”-20” diameter, interior slip coupling beaded at center, fastened to duct with sealing compound applied continuously around joint before assembling and after fastening. Wrap joints with 3-inch wide duct tape.
    b. Joints 21”-72” diameter, use 3 piece, gasketed, flanged joints consisting of 2 internal flanges (with integral mastic sealant) split to accommodate minor differences in duct diameter, and one external closure band designed to compress gasketing between internal flanges. Example: Ductmate Spiralmate or equal.
    c. Joints 73” diameter and up, use companion angle flanged joints only as defined on page 3-6 of the SMACNA Manual. Refer to manual for proper sizing and construction details. Ductwall to be welded longitudinal seams.

5. Fittings shall be continuously welded, standing seam, or spot welded and sealed. Metal thickness and reinforcing shall be equivalent to the requirements of the largest span.

    a. All elbows greater than 45° shall be radius type, R=1.5 times duct diameter.
    b. Elbows less than 6” shall be of die stamped construction. Elbows 6” or greater shall be 5-gore construction.
    c. Diverging and converging flow fittings shall be constructed with no excess material projecting from the body into the branch tap entrance. All such fittings shall be 45° “shoe” entrance, wye plus elbow, or 45° lateral branch. Special fittings such as heel tapped elbows and bullhead tees may be used only where shown on drawings. Adjustable elbows and straight saddle taps shall not be used. Low pressure adjustable elbows acceptable.

D. Round Duct Taps

1. Conical: Bellmouth spin-in fittings shall be used for duct taps and shall include quadrant dampers on all lines to air devices (diffusers and grilles) even though a volume damper may be specified for the air device. (This does not apply for high pressure duct). The spin collar fitting shall be made from G-90 galvanized sheet metal. The construction shall have a fabricated minimum overall length of 7". The location of spin-in fittings in the ducts shall be determined after terminals are hung or the location of the light fixtures is known so as to minimize flexible duct lengths and sharp bends.
2. High Efficiency Take-off (HETO): rectangular opening with integral, tapered rectangular to round transition and approximate 45° slope on body. Flange mount with gasket to duct

main. Provide with damper as indicated on plans, with low-leakage hardware and closed-end bearings, with standoff for external insulation as required. Material and thickness to match duct main, minimum thickness of 26-gauge steel.

E. Kitchen Exhaust Ducts:

1. General: Fabricate kitchen exhaust ducts and supports, used for smoke and vapor removal from cooking equipment as follows:

   a. Concealed locations: 16-gauge black carbon steel.
   b. Exposed locations: 18-gauge minimum stainless steel.

2. Joints, seams, and penetrations of grease duct shall be liquid-tight weld or braze on external surface of the duct system.
3. Duct joints: Shall be butt joints, welded flange joints, or overlapping duct joints (telescoping or bell type). Overlapping joints shall be installed to prevent ledges and obstructions from collecting grease or interfering with gravity drainage. Overlap length shall not exceed 2 in.
4. Fittings:

   a. Provide radius elbows, R=1.5 times duct diameter, unless indicated otherwise. Provide mitered elbows without turning vanes where indicated.

5. Cleanouts/access doors:

   a. Provide sandwich type access doors, high temperature, rated for grease application. Access door shall include ceramic fiber gasket rated up to 2,300°F and meet NFPA96. Provide 16 gauge carbon steel backing plate with smooth interior.

      1) Ductmate F2 Grease Duct Access Door or prior approved equal.

F. Dryer Exhaust Ducts:

1. General: Provide galvanized steel spiral round ductwork, 26 gauge minimum. Assemble with no sheet metal screws or protrusions in ductwork. All interior surfaces to be smooth.
2. Fittings: Provide long radius type elbows for all changes in direction.

   a. In-O-Vate Dryer-Ell or equal.

3. Sidewall Terminations: Provide 26-gauge steel body, powder coated, with magnetic damper.

   a. In-O-Vate Dryer Wall Vent or equal.

4. Roof Terminations: Provide high clearance roof jack with galvanized finish, water tight collar, and discharge flap. Provide with integral curb base. Provide minimum 14” tall roof curb by M.C.

   a. In-O-Vate Roof Jack model DJK486U.

5. Wall box: Provide recessed wall receptacle for dryer vent. Construct of 22-gauge steel.

a. In-O-Vate Dryer Wall Box model 425 or equal.

2.02 DUCTWORK FABRICATION

A. Shop fabricate ductwork of gauges and reinforcement complying with SMACNA "HVAC Duct Construction Standards".

B. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Except as otherwise indicated, fabricate elbows with centerline radius equal to 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.

C. 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.

D. Factory Fabricated: At installer's option, provide factory-fabricated duct and fittings, in lieu of shop-fabricated duct and fittings. Factory fabricated duct shall not be less than 26 ga. and shall be constructed according to SMACNA standards.

E. Duct Construction Schedule:

DUCT CONSTRUCTION SCHEDULE					
System	**SMACNA Duct Class**	**SMACNA Seal Class**	**Duct Test Pressure (P)**	**Leakage Class (C_L) (Rect. / Round)**	**Quantity Tested (Note: 1)**
Supply Ductwork from VAV AHUs to VAV Terminal Inlet	3”	A	3”	12 / 6	None
Return Air Duct Mains to AHU	2”	A	2”	24 / 12	None
Exhaust and Outside Air Ductwork, Duct Mains	2”	A	2”	24 / 12	None
Supply Ductwork Downstream of VAV Terminals Single Zone AHUs	2”	A	2”	24 / 12	None
Return and Exhaust Air Duct Branches to GRDs	1”	B	1”	24 / 12	None
Kitchen and Fume Hood Exhaust	2”	A	2”	24 / 12	None

Notes:
1. Amount of duct tested is a percentage of total square feet of ductwork for the indicated system. Contractor shall test sections of duct to meet total area as indicated.
2. Ductwork leakage (F) shall be calculated from the following equation, per SMACNA Duct Leakage Test Manual: $F = CL \times P^{(0.65)}$

DUCT CONSTRUCTION SCHEDULE					
System	**SMACNA Duct Class**	**SMACNA Seal Class**	**Duct Test Pressure (P)**	**Leakage Class (C_L) (Rect. / Round)**	**Quantity Tested (Note: 1)**
3. Provide test reports per SMACNA Duct Leakage Test Manual for each section of duct tested.					

2.03 MISCELLANEOUS DUCTWORK MATERIALS

A. General: Provide miscellaneous materials and products of types and sizes indicated and, where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.

B. 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, stains and discolorations, and other imperfections, including those which would impair painting.

C. Fittings: Provide radius type fittings fabricated of multiple sections with maximum 15 degree change of direction per section. Unless specifically detailed otherwise, use 45 degree laterals and 45 degree elbows for branch takeoff connections. Where 90 degree branches are indicated, provide conical type tees.

D. Duct Liner: Fibrous glass, complying with Thermal Insulation Manufacturers Association (TIMA) AHC-101; of 1" thick. The liner shall meet the Life Safety Standards as established by NFPA 90A and 90B. The 1” duct liner shall conform to the requirements of ASTM C 1071, with a NRC not less than .70 and a thermal conductivity no higher than .25 at 75°F mean temperature. The surface coating shall contain an immobilized EPA registered anti-microbial agent as tested in accordance with ASTM-G-21 and 423 “Type A Mountain.” Shop or field cut insulation shall be coated with a sealant approved for use in duct systems.

E. Duct Liner: Provide 1” thick AP Armaflex closed cell flexible elastomeric thermal insulation duct liner or equal. Manufacture without the use of CFCs, HFCs or HCFCs. Provide with antimicrobial protection for use in air ducts.

F. Round Duct Liner: Fibrous glass, complying with Thermal Insulation Manufacturers Association (TIMA) AHC-101; of 1" thick. The liner shall meet the Life Safety Standards as established by NFPA 90A and 90B. The 1” duct liner shall conform to the requirements of ASTM C 1071, with a NRC not less than .70 and a thermal conductivity no higher than .25 at a 75°F mean temperature. The surface coating shall contain an immobilized EPA registered anti-microbial agent as tested in accordance with ASTM-G-21 and 423 “Type A Mountain.” Shop or field cut insulation shall be coated with a sealant approved for use in duct systems. The liner shall be provided with factory-made, evenly spaced kerfs to allow the material to conform to the inside diameter of round air ducts.

G. Duct Sealant: Non-hardening, non-migrating mastic or liquid elastic sealant, type applicable for fabrication/installation detail, as compounded and recommended by manufacturer specifically for sealing joints and seams in ductwork.

H. 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.

I. 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" diameter or 3/16" thickness may be plain (not galvanized).
2. Duct hanger rod, attachments and struts in outdoor or high humidity areas, including but not limited to Natatoriums, pool locker rooms and pool equipment rooms, shall be hot dip galvanized after fabrication in accordance with ASTM A123. Duct strap in direct contract with the ductwork shall match the specified duct material. All hanger hardware in high humidity areas shall be hot-dip galvanized. Zinc plated or stainless steel hardware is not acceptable for these areas.
3. Duct hangers and struts located in corrosive areas, including but not limited to corrosive chemical storage rooms, shall be electro-deposit epoxy finish with stainless steel hardware. (Does not apply to chlorine storage, the chlorine storage room hangers shall match the natatorium.).
4. For exposed stainless steel ductwork, provide matching stainless steel support materials.

J. Flexible Ductwork:

1. Low Pressure Flexible Ducts: Duct shall be factory pre-insulated with a solid inner liner formed by a reinforced aluminum laminate material mechanically locked or bonded together by a corrosive resistant galvanized steel helix, covered with a minimum 1-1/2" thick fiberglass blanket and sheathed in a polyethylene vapor barrier. The insulation shall have a maximum 0.23 "C" factor, to meet FHA/HUD requirements and a vapor barrier permeability of 0.10 perms (ASTM E96-Procedure A). The duct shall have a positive working pressure rating of 6" w.g. (all diameters), negative working pressure rating of 1" w.g. (all diameters) and at a maximum operating temperature of 180°F (all diameters). Pressure rating based on test with temperature and velocity applied. The duct shall comply with the latest NFPA 90A Bulletin and be UL-181 listed as a Class I Air Duct.
2. Acceptable Manufacturers:

   a. Flexmaster.
   b. Glenflex.
   c. Thermaflex.

3. Materials

   a. Engineered system specifically designed for installation without the need for roof penetrations, and without causing damage to the roofing membrane.

      1) Bases shall use high density / high impact polypropylene or polycarbonate with carbon black, anti-oxidants for UV protection. Size bases as required

by loading conditions but no less than 16”x18”. Shop fabricated with inserts for square tubing.

2) Steel framing shall 12 gauge thickness, channel type of size as required for loading conditions. Frame shall be stainless steel or carbon steel with finish of hot dip galvanized in accordance with ASTM A123.

3) Factory fabricated to support exact duct sizes and equipment to be installed.

b. Accessories: Clamps, bolts, nuts, washers, and other devices as required for a complete system manufactured using stainless steel or carbon steel that is coated with hot-dip galvanized finish in accordance with ASTM A 153/A 153M.

4. Manufacturers:

a. (Basis of Design) PHP Systems / Designs
b. Miro Industries

2.04 DAMPERS

A. Low Pressure Balancing Dampers: Provide dampers of single blade type or multiblade type, constructed in accordance with SMACNA "HVAC Duct Construction Standards".

B. Counterbalanced Relief Dampers: Provide dampers with parallel blades, counterbalanced and factory-set to relieve at indicated static pressure. Construct blades of 16-gauge aluminum, provide 1/2" diameter ball bearings, 1/2" diameter steel axles spaced on 9" centers. Construct frame of 2" x 1/2" x 1/8" steel channel for face areas 25 sq. ft. and under; 4" x 1-1/4" x 16-gauge channel for face areas over 25 sq. ft. Provide galvanized steel finish on frame with aluminum touch-up.

C. Acceptable Manufacturers:

1. Greenheck
2. Penn Ventilator Co.
3. Pottorff.
4. Ruskin Mfg. Co.

2.05 RANGE HOOD BALANCING DAMPER

A. The balancing damper shall bear the Underwriters Laboratories U.L. label per U.L. listed range hood accessory per standard 710 and be fabricated in compliance with NFPA-96-1998. The installation shall be in accordance with the manufacturer’s recommendations and conform to NFPA-96 guidelines and all applicable local codes.

B. The size shall be as indicated on drawings and/or equipment schedule and match the exhaust collar size for the hood system. The damper shall be connected directly to the exhaust collar.

C. The damper shall be adjustable to allow for balancing airflows. The frame of the damper shall be constructed of continuously welded 16 ga. galvanized steel. The curved balancing panels shall be constructed of 18 ga. #304 stainless steel. One curve shall be a fixed position panel.

The operable panel shall be adjustable by means of a balancing arm extended from the damper frame. Non-curved internal surfaces are not allowed.

D. The balancing damper shall come equipped with a listed access panel for inspection of the duct and seals. The damper wiper seals shall be approved for use up to 1000° F and the fixed panel seal approved for use up to 2000° F.

E. When used with hoods not equipped with integral test ports, a calibration curve must be supplied to determine the airflow based on the damper position and pressure drop reading from the pressure ports.

F. Acceptable Manufacturers:

1. Halton Model KBD.
2. Approved Equal.

2.06 FIRE DAMPERS

A. General: Provide fire dynamic type dampers, of sizes and types indicated. Dampers shall be constructed and tested in accordance with the current edition of UL-555 Standard for Fire Dampers. Provide fusible link rated at temperature indicated. Dampers marked "for use in static systems only" are not permitted. Submittal information shall include the fire protection rating, maximum velocity/pressure ratings and the manufacturer's UL installation instructions. The dampers shall be installed in accordance with these instructions.

B. Ratings:

1. Fire Rating: **1-1/2 hour OR 3 hour)** in accordance with UL-555
2. Temperature Release Rating: **165°F / 212°F / 286°F**.
3. Airflow rating: 4,000 FPM minimum
4. Differential Pressure Rating: 4 in. w.g

C. Curtain Style Dampers

1. Duct sizes: Ductwork up to 20" in height.
2. Frame: Minimum 22-gauge roll formed, galvanized steel.
3. Blades: Minimum 24-gauge roll formed, galvanized steel, curtain type.
4. Style: Type "B", blades out of airstream.
5. Duct connection: Provide rectangular, round, or oval connections as required for each damper to connect to ductwork as shown on plans.

D. Airfoil Blade Style Dampers

1. Duct size: Ductwork over 20" in height.
2. Frame: Hat-shaped channel, roll formed galvanized steel with interlocking gusseted corners. Structurally equivalent to 13-gauge U-channel type frame. Low profile head and sill on sizes less than 13 inches high.
3. Blades: 6-inch maximum width, double skinned true air foil, roll formed galvanized steel. Structurally equivalent to 14 gauge.
4. Jamb Seals: Stainless steel, flexible metal compression type.

5. Axles: Minimum ½" diameter plated steel hex-shaped, mechanically attached to blade.
6. Bearings: Self-lubricating stainless steel, sleeve-type turning in extruded hole in frame.
7. Linkage: Concealed in frame.

E. Accessories:

1. Factory sleeve, minimum 20 gauge.
2. Mounting angles as required for installation.
3. Breakaway connection.
4. Indicator switches.

F. Acceptable Manufacturers:

1. Greenheck.
2. Pottorff.
3. Prefco.
4. Ruskin Mfg. Co.

2.07 FIRE AND SMOKE DAMPERS

A. General: Provide combination fire smoke dampers meeting or exceeding the following specifications as indicated on the locations as shown on the plans. Dampers shall meet the requirements of NFPA 90A, 92A, and 92B. Dampers shall be warranted to be free from defects in material and workmanship for a period of 5 years after date of shipment. Each fire smoke damper shall be AMCA licensed and shall bear the AMCA Certified Ratings Seal for Air Performance. AMCA certified testing shall verify pressure drop does not exceed 0.03" W.G. at a face velocity of 1,000 fpm on a 24" x 24" damper. Electric actuators shall have been energized hold open tested for a period of at least 1 year with no spring return failures. Fire smoke damper shall be equipped with an electrical fusible link "controlled closure" quick detect heat actuated release device to prevent duct and HVAC component damage, and shall be automatically remote resettable after test, smoke detection, or power failure conditions. Instantaneous damper closure through the use of fusible links is unacceptable.

B. Ratings:

1. Fire Rating: **1-1/2 hour OR 3 hour** in accordance with UL-555.
2. Smoke Rating: leakage in accordance with UL-555S.
3. Leakage Rating: Leakage class 1, 8 CFM/SF at 4 in. w.g.
4. Elevated Temperature Rating: **250°F OR 350°F**.
5. Temperature Release Rating: **165°F / 212°F / 250°F / 350°F**.
6. Airflow Rating: 4,000 FPM.
7. Differential Pressure Rating: 4 in. w.g.

C. Construction:

1. Frame: Hat-shaped channel, roll formed galvanized steel with interlocking gusseted corners. Structurally equivalent to 13-gauge U-channel type frame. Low profile head and sill on sizes less than 13 inches high.
2. Blades: 6-inch maximum width, double skinned true airfoil, roll formed galvanized steel. Structurally equivalent to 14 gauge.

3. Blade Seals: Silicone rubber integrally rolled and mechanically fastened to blade edge (glue-on or grip-type seals are not acceptable).
4. Jamb Seals: Stainless steel, flexible metal compression type.
5. Axles: Minimum ½" diameter plated steel hex-shaped, mechanically attached to blade.
6. Bearings: Self-lubricating stainless steel, sleeve-type turning in extruded hole in frame.
7. Linkage: Concealed in frame.
8. Fire Closure Device: Resettable
9. Mounting: Vertical and/or Horizontal.
10. Actuator:

    a. Type:

        1) Electric 120V, 60 Hz, two-position, fail close.

    b. Mounting:

        1) External.

D. Accessories:

1. Factory sleeve, minimum 20 gauge.
2. Mounting angles as required for installation.
3. Breakaway connection.
4. Indicator switches.
5. Two-temperature closure device:

    a. UL classified two-temperature device permits the damper to be re-opened after initial temperature closure allowing the damper to remain operable for smoke management purposes until the high temperature limit is reached.
    b. Manual damper testing is permitted by physically depressing the low temperature thermal disc from the inside of the damper sleeve and resetting the sensor from the exterior side of the damper sleeve.
    c. Dual position blade indicator switch package shall connect directly to the blade axel for positive annunciation (interconnecting arms, wire-forms, or brackets shall not be accepted) and provide full open and full closed blade indication to a remote location.

6. Dual-position indicator switch:

    a. Shall connect directly to the blade axel for positive annunciation (interconnecting arms, wire-forms, or brackets shall not be accepted) and provide full open and full closed blade indication to a remote location.

E. Acceptable Manufacturers:

1. Greenheck.
2. Pottorff.
3. Prefco.
4. Ruskin Manufacturing Co.

2.08 TURNING VANES

A. Manufactured Turning Vanes: Provide turning vanes constructed of 1-1/2" wide single wall curved blades set at 3/4" o.c., supported with bars perpendicular to blades set at 2" o.c., and set into side strips suitable for mounting in ductwork.

B. Acoustic Turning Vanes: Provide acoustic turning vanes constructed of airfoil shaped aluminum extrusions with perforated faces and fiberglass fill.

C. Acceptable Manufacturers:

1. Aero Dyne Co.
2. Airsan Corp.
3. Anemostat Products Div.; Dynamics Corp. of America.
4. Barber-Colman Co.
5. Duro Dyne Corp.
6. Titus Products Division, Phillips Industries, Inc.
7. Hercules Industries.

2.09 QUADRANT LOCKS

A. Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12". Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

B. Acceptable Manufacturers:

1. Ventfabrics, Inc.
2. Young Regulator Co.

2.10 DUCT ACCESS DOORS

A. General: Provide duct access doors of size required.

B. Construction: Construct of same or greater gauge as ductwork served, provide insulated doors for insulated ductwork. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct. Provide one side hinged, other side with one handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors. Provide 12 x 12 for hand access and 24 x 24 for head and shoulder access.

C. Acceptable Manufacturers:

1. Air Balance Inc.
2. Duro Dyne Corp.
3. Pottorff.
4. Ruskin Mfg. Co.
5. Ventfabrics, Inc.

2.11 PRESSURE RELIEF DOOR

A. Provide pressure relief door in the ductwork where indicated on the plans or where the ductwork could be subject to excessive pressure build-up due to quick closure of fire dampers. The door shall be constructed of 12-gauge galvanized steel with a 12-gauge galvanized steel frame. The door shall be sealed with a ¼" thick gasket. The door shall be insulated with 1" fiberglass 1 ½ lb. insulation or as consistent with the duct insulation. The door shall have a spring-loaded mechanism to automatically close the door after pressure has been relieved. Door shall be adjustable for pressures of 3" w.c. to 8" w.c. The door pressure setting shall be adjustable in the field. The door shall be welded to the ductwork or installed with high pressure sealing cement and screws.

B. Acceptable Manufacturers:

1. Kees.
2. Ruskin.

2.12 FLEXIBLE CONNECTIONS

A. General: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof 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.

B. Acceptable Manufacturers:

1. American/Elgen Co.; Energy Div.
2. Duro Dyne Corp.
3. Flexaust (The) Co.
4. Ventfabrics, Inc.

2.13 EXTERIOR GRADE FLEXIBLE CONNECTIONS

A. General: Provide flexible duct connections suitable for exterior applications where ductwork connects to vibration isolated equipment. Construct flexible connections of heavy glass flameproof fabric coated with chlorosulfurated polyethylene crimped into duct flanges for attachment to duct and equipment. Make airtight weatherproof joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibrations of connected equipment.

B. Acceptable Manufacturers:

1. Ventfabrics, Inc.
2. Engineer approved equal.

2.14 GRILLES, REGISTERS AND DIFFUSERS

A. General: Except as otherwise indicated, provide manufacturer's standard air device 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 air devices that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Ceiling/Wall Compatibility: Provide air devices with border styles that are compatible with adjacent ceiling/wall systems, and that are specifically manufactured to fit into ceiling/wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling/wall construction which will contain each type of air device.

D. Types: Provide air device of type, capacity, and with accessories and finishes as listed on grilles, register and diffuser schedule.

E. Fire-rated devices: Provide manufacturer’s fire-rated air devices where indicated per the grilles, register, and diffuser schedule. The fire-rated diffuser shall conform to the following:

1. UL263 listed as a Fire Rated Assembly in the Fire Resistance Directory, meeting UL time-vs-temperature test criteria. Shall be listed in the UL certifications directory under BZGU - Air Terminal Units or BZZU – Ceiling Air Diffusers. Submittals shall include the UL certification page stating manufacturer and model.
2. Meets or exceeds NFPA 90A requirements.
3. For use in 3-hr or less restrained or unrestrained fire-rated, exposed grid, suspended ceiling systems.
4. The air device shall have the following components:

    a. Butterfly-type ceiling radiation damper.
    b. Non-asbestos thermal blanket.
    c. 165°F fusible link.

F. Acceptable Manufacturers:

1. Krueger Mfg. Co.
2. Price.
3. Titus Products Div.; Philips Industries, Inc.
4. Air Concepts

2.15 LOUVERS

A. General: Except as otherwise indicated, provide manufacturer's standard louvers 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 louvers that have minimum free area as scheduled, and minimum pressure drop for each type as listed in manufacturer's current data, complying with louver

schedule. Performance data must bear AMCA Certified Ratings Seal for Air Performance and Water Penetration.

C. Substrate Compatibility: Provide louvers with frame and sill styles that are compatible with adjacent substrate, and that are specifically manufactured to fit into construction openings with accurate fit and adequate support, for weatherproof installation. Refer to general construction drawings and specifications for types of substrate which will contain each type of louver.

D. Materials:

1. Aluminum: ASTM B 221, Alloy 6063-T52. Weld units or use stainless steel fasteners.

a. Heavy duty models shall be constructed of no less than 0.125” thick blades and frame.

2. Steel:

a. Frame: 16 gauge galvanized.
b. Blades: 18 gauge galvanized.

E. Louver Screens: On inside face of exterior louvers, provide 1/2" square mesh. Mesh shall be anodized aluminum wire bird screens mounted in removable extruded aluminum frames.

F. Acceptable Manufacturers:

1. Greenheck
2. Pottorff.
3. Ruskin Mfg. Co.

2.16 PROPELLER FANS

A. General: Provide AMCA certified propeller fans of size and arrangement as indicated, and of capacities and having accessories as scheduled.

B. Fan Units: Provide factory-fabricated and tested fan units consisting of fan blades, hub, housing, orifice ring, motor, and drive.

C. Housings: Construct of galvanized sheet steel with flanged edges, and integral orifice ring.

D. Wheels: Provide welded steel construction fan blades with spun steel spider bolted to cast-iron hub.

E. Belt Drive AC Motor: Motor enclosures, OPED drip proof type. Motor shall be permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase. Provide belt drive type fans with motor cover and belt guard meeting OSHA requirements.

F. Direct Drive EC Motor: Motor enclosures, Open type. Motor to be a DC electronic commutation type motor (EC) specifically designed for fan applications. AC induction type motors are not acceptable. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase. Internal motor

circuitry to convert AC power supplied to the fan to DC power to operate the motor. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by a potentiometer dial mounted at the motor or by an external 0-10 VDC signal. Speed control type shall be field convertible with both options available as a standard. Motor shall be a minimum of 85% efficient at all speeds.

G. Accessories:

1. Provide factory mounted **gravity relief / motorized** dampers per schedule.
2. Inlet screen.
3. Belt guard.
4. Wall housing.

H. Acceptable Manufacturers:

1. Aerovent.
2. Greenheck.
3. Loren Cook Co.
4. Penn Barry

2.17 IN-LINE CABINET FAN

A. Provide centrifugal in-line cabinet fan of type, size and capacity as scheduled.

B. Provide AMCA certified ratings seal.

C. Type: Provide galvanized steel housing lined with acoustical insulation, adaptable for suspended installation. Provide centrifugal fan wheels mounted on motor shaft with fan shrouds, all removable for service. Provide integral backdraft damper fan discharge. Provide fan motor type as scheduled and as specified herein.

D. Motor: Provide permanent split-capacitor motor, permanently lubricated, with grounded cord and plug. Furnish remote fan speed control, solid state, capable of controlling fan speed from full speed to approximately half speed.

E. Electrical: Provide junction box for electrical connection on housing, and receptacle for motor plug-in.

F. Accessories: Provide manufacturer's standard roof jack, brick vent, wall cap, and transition fittings as indicated on drawings or schedules.

G. Acceptable Manufacturers:

1. Greenheck.
2. Loren Cook Co.
3. Penn Barry

2.18 CENTRIFUGAL IN-LINE FAN

A. General: Provide AMCA certified inline centrifugal fan of type, size, and capacity as scheduled, and as specified herein

B. Type: Centrifugal inline fan, direct or belt driven as scheduled.

1. Housing: Square design constructed of heavy gauge galvanized steel or aluminum with square duct mounting collars. Housing and bearing supports shall be constructed with bolted or welded steel fasteners. Construction shall include two removable access panels located perpendicular to the motor mounting panel. Panel shall be of sufficient size to permit access to all interior components.
2. Wheel: Provide non-overloading backward inclined centrifugal wheel constructed of aluminum. Blades securely riveted or welded to heavy gauge back plate and wheel cone. Wheel shall be statically and dynamically balanced in accordance with AMCA Standard 204-05.
3. Discharge Configuration: The fan discharge configuration shall be field convertible to accommodate a true inline discharge, right discharge or left discharge arrangement.
4. Belt Drive AC Motor: Motor enclosures, Oped drip proof type. Motor shall be permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase. Provide belt drive type fans with motor cover and belt guard meeting OSHA requirements.
5. Direct Drive EC Motor: Motor enclosures, Open type. Motor to be a DC electronic commutation type motor (EC) specifically designed for fan applications. AC induction type motors are not acceptable. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase. Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by a potentiometer dial mounted at the motor or by an external 0-10 VDC signal. Speed control type shall be field convertible with both options available as a standard. Motor shall be a minimum of 85% efficient at all speeds.

C. Electrical: Provide factory-wired NEMA 1 disconnect switch wired from fan motor to junction box for electrical connection.

D. Vibration Isolation: Provide with hanging spring isolators specifically sized to accommodate the fan weight.

E. Dampers: Provide gravity or motorized actuated damper as scheduled on drawings.

F. Acceptable Manufacturers:

1. Greenheck.
2. Loren Cook Co.
3. Penn Barry

2.19 CENTRIFUGAL ROOF VENTILATORS

A. General: Provide AMCA certified centrifugal roof type, curb mounted, power ventilators of type, size, and capacity as scheduled, and as specified herein.

B. Type: Centrifugal fan, direct or belt driven as scheduled. Provide aluminum, galvanized or steel weatherproof housings as scheduled. Provide square base to suit roof curb. Provide motor and drive type as scheduled and as specified herein.

1. Housing Design: Hooded dome type.
2. Housing Design: Upblast type.

C. Wheel: Provide non-overloading backward inclined centrifugal wheel. Wheel shall be constructed of aluminum, galvanized or steel as scheduled. Wheel shall be statically and dynamically balanced in accordance with AMCA Standard 204-05.

D. Belt Drive AC Motor: Motor enclosures, OPED drip proof type. Motor shall be permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.

E. Direct Drive EC Motor: Motor enclosures, Open type. Motor to be a DC electronic commutation type motor (EC) specifically designed for fan applications. AC induction type motors are not acceptable. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase. Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by a potentiometer dial mounted at the motor or by an external 0-10 VDC signal. Speed control type shall be field convertible with both options available as a standard. Motor shall be a minimum of 85% efficient at all speeds.

F. Range Hood Exhaust Fans: Upblast fans shown on drawings to serve range hoods shall be U.L. listed for grease removal and shall have been tested under high temperature exhaust (300°F) and abnormal flare-up (600°F) conditions. The fans shall be constructed and installed in accordance with NFPA 96.

G. Range Hood Exhaust Fan Accessories. Provide the following accessories for range hood exhaust fans:

1. Roof curb with vented extension.
2. Hinge kit with hinged base.
3. Grease trap and trough.
4. Heat baffle.

H. Vibration Isolation: Fan and drive frame shall be mounted rubber vibration isolators sized to match the weight of the fan.

I. 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.

J. Roof Curb: Provide 14” tall welded aluminum or galvanized roof curb with minimum 1.5” of internal rigid insulation.

1. Provide with wind restraint clips and mounting hardware.

K. Bird Screens: Provide removable bird screens, 1/2" mesh, 16- gauge aluminum or brass wire.

L. A two-piece top cap shall have stainless steel quick release latches to provide access into the motor compartment without the use of tools.

M. Dampers: Provide gravity-actuated dampers / motorized dampers with linkage / dampers in curb bases as scheduled on drawings.

N. Acceptable Manufacturers:

1. Greenheck.
2. Loren Cook Co.
3. Penn Ventilator Co., Inc.

O. Centrifugal Ceiling Exhausters: Provide AMCA certified centrifugal ceiling exhausters, designed for ceiling or wall mounting, of type, size and capacity as scheduled.

P. Type: Provide galvanized steel housing lined with acoustical insulation, adaptable for ceiling or wall installation. Provide centrifugal fan wheels mounted on motor shaft with fan shrouds, all removable for service. Provide integral backdraft damper at fan discharge. Provide fan motor as scheduled and as specified herein.

Q. Grille: Provide integral grille with flange on intake with attachment to fan housing.

R. Motor: Provide permanent split-capacitor motor, permanently lubricated, with grounded cord and plug. Furnish remote fan speed control, solid state, capable of controlling fan speed from full speed to approximately half speed.

S. Electrical: Provide junction box for electrical connection on housing, and receptacle for motor plug-in.

T. Accessories: Provide manufacturer's standard roof jack, brick vent, wall cap, and transition fittings as indicated on drawings or schedules.

U. Acceptable Manufacturers:

1. Greenheck.
2. Loren Cook Co.
3. Penn Ventilator Co., Inc.

2.20 HIGH VOLUME LOW SPEED (HVLS) FANS

A. General: Section applies to ceiling fans 6’-0” in diameter and larger. Provide AMCA certified propeller fans of size and arrangement as indicated, and of capacities and having accessories as scheduled. The fans shall be listed to applicable UL standards and requirements by UL.

B. Fan Units: Provide factory-fabricated and tested fan units consisting of fan blades, hub, housing, orifice ring, motor, and drive.

1. Fan hub shall not be provided with the manufacturer’s logo or name.

C. Aluminum Airfoil. Custom color finish, as selected by the Architect.

D. Provide with manufacturers factory mounting and support frame kit. Select kit specific to mounting application.

E. Motor:

1. Basis of Design: Provide variable speed electronically communicated (EC) motor, transverse flux brushless DC motor. Motors shall be rated for continuous duty. Where installed outdoors or in the natatorium environment provide motors rated for such use (wash down configuration).
2. Contractor Option: Provide variable speed motor with factory mounted variable frequency drive. Motors shall be in compliance with NEMA MG1 Part 30 and 31. Provide motors with TEFC enclosure rated for continuous duty. Where installed outdoors or in the natatorium environment provide motors rated for such use (wash down configuration).

F. Controller Connection: Cat 5.

G. Controls: Provide with manufacturers touch screen controller capable of controlling 6 or more fans simultaneously from a single controller. Provide network enabled fans using daisy chain CAT5 communication wiring installed between fans and controller. Include necessary repeaters/isolators for network system as required for a complete system, based on the number of fans and network wiring distances. Controller shall include the following features at a minimum.

1. Speed control
2. On/Off control
3. Individual naming of fans
4. Individual or grouped control of fans
5. Unoccupied / occupied mode scheduling
6. Password protection

H. Maintenance free gear box or direct drive.

I. Variable Frequency Drive.

J. Sound Level (Maximum Speed): <55 dBA.

K. Features:

1. 10-year full warranty with factory installation.
2. Units located in natatorium shall be completely maintenance free and made of highly corrosion resistive materials (aluminum or stainless steel).
3. Provide with manufacturers safety system including safety cables and all required structural attachments

L. Acceptable Manufacturers:

1. Macro Air
2. Big Ass Fans.
3. Entrematic.
4. Approved Equal

2.21 PREFABRICATED ROOF CURBS

A. General: Provide manufacturer's standard shop-fabricated units, modified if necessary, to comply with requirements.

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-degree cant strips and deck flanges with offsets to accommodate roof insulation. Weld corners and seams to form watertight units.

1. Clean and paint units with manufacturer's standard rust- inhibitive metal primer paint.
2. 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" 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 and more, fabricate support units to form level top edge.

E. Gauge and Height: Fabricate units of metal gauge and to height above roof surface as indicated.

1. Where gauge or height are not indicated, fabricate units of 14- gauge metal, and nominal height of 14".

F. Provide treated wood nailer, not less than 1-5/8" thick and of width indicated, but not less than width of support wall assembly. Anchor nailer 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. Fabricate exterior support profile to receive insulation of thickness indicated or, if not indicated, of 1" thickness.

I. Insulate units inside structural support wall with rigid glass fiber insulation board of approximately 3-lb. density and 1-1/2" minimum thickness, except as otherwise indicated.

J. Provide support liners where shown, formed of 22-gauge 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" diameter holes per sq. ft., to provide sound absorbing surfaces.

a. Provide sound insulation insert for curbs so indicated. Construct of 1" thick rigid fiberglass panels secured in galvanized steel framework, with rounded edges to minimize air flow resistance.

K. Provide burglar-proof grille in curb units for roof openings of more than 1'-0" width. Fabricate grille of 3/4" diameter hardened steel bars, spaced 6" o.c. in one direction and 12" o.c. in other direction. Weld ends of bars to curb walls, and weld bars at intersections. Clean and paint with rust-inhibitive metal primer.

L. 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 metal to match metal and finish of curb units, except as otherwise indicated.

M. Wind Restraint: Provide with wind restraint clips and mounting hardware.

N. Acceptable Manufacturers:

1. Rate.
2. Robertson Co., H.H.
3. Swartwout Industries, Inc.
4. Thy Curb.
5. Vent Products.
6. Curb Technologies.

2.22 SOUND ATTENUATORS

A. General: Provide factory-fabricated and tested sound attenuators, selected with performance characteristics which match or exceed those indicated on the schedule.

B. Casing: Outer casings of silencers shall be made of galvanized steel in accordance with ASHRAE Guide recommended construction for high pressure rectangular duct work. Seams shall be lock formed and mastic filled.

C. Interior partitions for rectangular silencers shall be made of not less than 26 gauge galvanized perforated steel.

D. Interior construction of tubular silencers shall be compatible with the outside casings.

E. Airtight construction shall be provided by use of a duct sealing compound on the job site. Material and labor furnished by contractor. Silencers shall not fail structurally when subjected to a differential air pressure of 8" w.g. inside to outside of casing.

F. Filler Material: Filler material shall be of inorganic mineral of glass fiber of a density sufficient to obtain the specific acoustic performance and be packed under not less than 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin and moisture proof.

G. Combustion rating for the silencer acoustic fill shall not be greater than the following when tested in accordance with ASTM E 84, NFPA Standard 255 or U.L. No. 723:

1. Flamespread Classification 25
2. Smoke Development Rating 50

H. Ratings: Silencer ratings shall be determined in a duct-to-reverberant room test facility which provides for airflow in both directions through the test silencer during rating. The test set-up and procedure shall be such that all effects due to end reflection, directivity, flanking transmission, standing waves and test chamber sound absorption are eliminated. Acoustic ratings shall include Dynamic Insertion Loss (DIL) and Self-Noise (SN) Power levels both for FORWARD FLOW (air and noise in same direction) and REVERSE FLOW (air and noise in opposite directions) with an airflow of at least 2000 fpm entering face velocity.

I. Static pressure loss of silencers shall not exceed those listed in the silencer schedule as the airflow indicates. Airflow measurements shall be made in accordance with applicable portions of ASME, AMCA and ADC airflow test codes. Test shall be reported on the identical units for which acoustic data is presented.

J. Certification: The manufacturer shall supply with submittals certified test data on Dynamic Insertion Loss, Self-Noise Power Levels and Aerodynamic Performance for Reverse and Forward Flow test conditions. Test data shall be for a standard product. All rating tests shall be conducted in the same facility and shall utilize the same silencer and shall be open to inspection upon request from the Architect/Engineer.

K. Acceptable Manufacturers:

1. Aero Sonics.
2. Industrial Acoustics Company (IAC).
3. Koppers.
4. Semco.
5. Kinetics.

2.23 VARIABLE AIR VOLUME 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. Construction:

1. Construct casing of 22-gauge galvanized steel. Provide longitudinal lock seam construction. Provide round or rectangular inlet and rectangular discharge duct collars with slip and drive connections.
2. Provide hanger brackets for attachment of supports.
3. Linings: Line inside surfaces of casings with lining material to provide acoustic performance, thermal insulation, and to prevent condensation on outside surfaces of casing. Secure lining with adhesives and weld pins to prevent delamination, sagging, or settling. All lining shall conform to UL 181 (erosion, mold growth, and humidity), ASTM E 84 (flame/smoke spread index of 25/50)

    a. Fiberglass Liner: ½ inch thick, 1-1/2 lb. density.
    b. Fiber-Free Foam Insulation: ½ inch thick, 1-1/2 lb density, closed cell foam.
    c. Foil Board Insulation: 5/8-inch-thick minimum, 4 lb density, rigid board insulation with foil face. Provide with full-seam-length Z-strips and metal caps to enclose and seal the insulation cut edges.

d. Solid Metal Liner: ½ inch thick fiberglass insulation, 1-1/2 lb density, with solid metal liner extending over fiberglass insulation and enclosing all exposed edges.
e. Perforated Metal Liner: ½ inch thick fiberglass insulation, 1-1/2 lb density, with perforated metal liner extending over fiberglass insulation and enclosing all exposed edges.

4. Leakage: Construct casings such that when subjected to 0.5-in w.g. pressure for low pressure units, and 3.0-in w.g. pressure for high pressure units, total leakage does not exceed 4% of specified air flow capacity with outlets sealed and inlets wide open. Construct air dampers such that when subjected to 6.0-in w.g. inlet pressure with damper closed, total leakage does not exceed 10% of specified air flow capacity.

C. Air Dampers:

1. Construct damper of heavy gauge, galvanized steel with solid shaft rotating in bearings.
2. Damper shaft shall incorporate visual position indicator.
3. Damper shall incorporate flexible gasket for tight airflow shutoff and operate over a full 90°.
4. Air leakage shall not exceed 2% of unit maximum rated airflow at 3.0” W.C.

D. Airflow Sensor:

1. Factory differential pressure airflow device measuring total and static pressures, mounted at the inlet valve.
2. Sensor shall include 12 total pressure sensing ports and 4 static pressure sensing ports, and shall include a center averaging chamber that amplifies the sensed airflow signal.
3. Accuracy shall be +/- 5% throughout the terminal operating range.

E. Options:

1. NEMA 1 controls enclosure with removable cover for protection of electronic controls. Enclosure shall have double backpane construction and shall have no exposed screw tips.
2. Bottom access door, 4”x6-3/4”, secured to casing with screws.
3. Integral sound attenuator, minimum 3’ length, as scheduled.

F. Hot Water Heating Coils:

1. Coil shall be mounted in minimum 22-gauge galvanized steel casing on the terminal discharge with slip and drive connection for ductwork.
2. Provide copper tubes and aluminum fins.
3. Coils shall be leak tested to 250 PSI with a minimum burst pressure of 1,800 PSI.

G. Fan Powered Terminals:

1. Series or parallel flow arrangement as scheduled or indicated on the mechanical plans.
2. Fan: Provide forward curve, centrifugal type. Direct drive.
3. Motor: Permanently lubricated split-capacitor with SCR fan speed controller. Provide with thermal overload protection.
4. Motor: Electrically commutated motor (ECM). Provide speed controller with dual outputs and allow for manual dial motor speed adjustment of 2-10V DC signal for variable speed control.

5. Electrical: Provide single connection point per the schedule. Units with electric heating coils shall be factory wired for single-point power.
6. Filter: Provide plenum inlet filter rack and MERV 3 fiberglass filters.

H. Controls:

1. Provide controls enclosure for mounting of field controls by the temperature controls contractor.

I. Acceptable Manufacturers:

1. Environmental Technologies.
2. Krueger.
3. Price Industries.
4. Titus Products Div.
5. Trane (The) Co.

2.24 DIRECT VENT SYSTEMS FOR CONDENSING APPLIANCES

A. General: Provide complete vent system, consisting of pipe sections, fittings and accessories required by manufacturer for complete installation. System shall be one-pipe or two-pipe as indicated on the mechanical drawings for use with a Category IV, positive pressure condensing appliance.

B. CPVC Vent System:

1. Material: Construct pipe of solid core schedule 40 CPVC as noted on plans or a material determined by manufacturer's recommendations. All components exposed to exterior conditions shall be UV rated or be provided with UV resistant paint and primer.

a. CPVC Plastic Pipe: Schedule 40, ASTM F 441.
b. CPVC Plastic Pipe Fittings: Schedule 40, ASTM F 438, socket-type fittings and solvent welded joints.
c. Solvent Cements for Joining Plastic Piping:

1) CPVC Piping: ASTM F 493.

2. Accessories: Provide manufacturer's standard accessory items as necessary for complete installation.

a. Concentric Vent Kit.
b. Bird screens.

C. Polypropylene Vent System:

1. General: Provide single wall Polypropylene flue piping of size as indicated, with all accessories, supports, penetrations, appliance connectors, and drains as required for a complete system.
2. Material: Construct pipe of rigid, single wall Polypropylene pipe, 2.2mm minimum wall thickness. Provide socket-type fittings with integral EPDM gasket. Material shall be rated

up to 230°F continuous. All components exposed to exterior conditions shall be UV rated.

3. Accessories:

   a. Concentric Vent Kit.

4. Acceptable Manufacturers: Shall be approved by the appliance manufacturer.

   a. Duravent PolyPro.
   b. Centrotherm InnoFlue.

2.25 KITCHEN RANGE HOOD

A. Canopy: The canopy shall bear an Underwriters Laboratories (UL) label and be fabricated in complete accordance with NFPA #96 and shall bear the National Sanitary Foundation Seal of Approval (NSF). The canopy shall be 18-gauge stainless steel, type 304 with #4 finish. All joints and seams shall have full liquid tight external welds which shall be ground down and smoothed, and in the case of stainless steel be highly polished. Each canopy shall have a filter housing of the same material as the canopy, complete with stainless steel UL classified grease filters the full length of the housing. This filter housing shall further terminate at the bottom with a pitched drip tray the full length of the canopy and be equipped with a grease cup built for easy removal for daily cleaning. Vapor proof lights shall be installed on 3-foot centers, completely wired and ready for an external power source. The front of the canopy shall have light switch and fan on-off switch with indicating light.

B. Fire Suppression System:

   1. Provide an automatic dry chemical system complete with chemical cylinder, chemicals, discharge nozzles built into hood, remote manual pull station and solenoid valve(s) on the gas supply line.
   2. Entire system to comply with local building codes. Fire Underwriters and Insurance Services Offices.
   3. Run all piping concealed where possible, chrome plated where exposed. Provide switch and wiring for gas solenoid valve.
   4. Contractor to prepare shop drawings for entire installation, minimum 1/4" = 1’-0”-scale and submit four (4) copies for approval prior to starting work. Include all equipment, piping, outlet locations, valves and wiring.

C. Acceptable Manufacturers:

   1. Greenheck.
   2. Accurex.
   3. Captive Air Systems.
   4. Kees.
   5. Gaylord.

PART 3 - EXECUTION

3.01 INSPECTION

A. General: Examine areas and conditions under which ductwork accessories and equipment are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF DUCTWORK

A. General: Assemble and install ductwork in accordance with SMACNA standards and noiseless (no objectionable noise) systems, capable of performing each indicated service. Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8" 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. Support vertical ducts at every floor.

B. Inserts: Install concrete inserts for support of ductwork in coordination with framework, as required to avoid delays in work.

C. Field Fabrication: Complete fabrication of work at project as necessary to match shop-fabricated work and accommodate installation requirements.

D. Field Modifications: Ductwork modified in the field shall maintain the same free area as shown on the Drawings. In no case shall the aspect ratio of modified ductwork exceed 4 to 1 without permission of the Engineer.

E. Routing: 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 useable 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 ½" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1" 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 route ductwork through transformer vaults and their electrical equipment spaces and enclosures.

G. Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gauge as duct. Overlap opening on 4 sides by at least 1-1/2". Fasten to duct and substrate.

1. Where ducts pass through fire-rated floors, walls, or partitions, provide firestopping between duct and substrate, in accordance with requirements of Division-07 Section "Firestopping".

H. Installation: Install metal ductwork in accordance with SMACNA HVAC Duct Construction Standards as follows:

1. Natatorium Supply and Return: Aluminum sheet metal.
2. Dishwasher Hood Exhaust: Stainless steel sheet metal.
3. Range Hood Exhaust: 16-gauge welded steel.
4. Pool Chemical Room: PVC pipe to serve as ductwork in lieu of sheet metal.
5. Science Room Fume Hoods: PVC pipe to serve as ductwork in lieu of sheet metal.
6. All **other concealed** supply, return and exhaust: Galvanized sheet metal.
7. Exposed ductwork: Galvanized, mill-phosphatized sheet metal ready for field painting.

I. Sealant: Seal all supply, return and exhaust ductwork with duct sealant or duct cement in accordance with SMACNA HVAC Duct Construction Standards.

J. Hangers, supports, strut, hardware and ductwork in Natatoriums, pool locker rooms, pool equipment rooms and chemical storage rooms, shall be field painted by the general contractor. Coordinate ductwork and hanger material with painting contractor prior to painting. The installing paint contractor shall provide preparation and painting suitable for the material used.

3.03 DUCT LEAKAGE TESTING

A. Refer to Duct Fabrication in Part 2 above for duct construction schedule and allowable leakage rates and extent of leak testing.

B. Installed ductwork shall be tested prior to installation of access doors, take-offs, etc.

C. Contractor shall submit leak test reports to the engineer for review for each section of duct tested.

D. The testing shall be performed as follows:

1. Perform testing in accordance with HVAC Air Duct Leakage Test Manual.
2. Use a certified orifice tube for measuring the leakage.
3. Define section of system to be tested and blank off.
4. Determine the percentage of the system being tested.
5. Determine the allowable leakage (cfm) for that section being tested.
6. Pressurize to operating pressure and repair any significant or audible leaks.
7. Repressurize and measure leakage.
8. Repeat steps 6 and 7 until the leakage measured is less than the allowable defined in step 5.

E. NOTE: It is recommended that the first 100’-300’ of ductwork installed be tested to ensure the quality of the workmanship at an early stage.

3.04 INSTALLATION OF DUCT LINER

A. General: Install duct liner in accordance with SMACNA HVAC Duct Construction Standards. Duct sizes shown on plans are clear inside dimensions. Increase duct sizes accordingly.

B. Extent of Duct Liner:

1. Refer to specification section 23 0700, HVAC Insulation, for extent of duct liner and required thicknesses.

3.05 INSTALLATION OF KITCHEN EXHAUST DUCTS

A. General: Fabricate, install, support, and test all grease ductwork in accordance with the International Mechanical Code. Comply with SMACNA "HVAC Duct Construction Standards", and NFPA 96 "Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment".

1. Refer to Specification Section 23 0700, HVAC Insulation, for fire rated grease wrap requirements.

B. Material:

1. Concealed Type I hood exhaust duct: 16-gauge black carbon steel
2. Exposed Type I hood exhaust duct: 18-gauge stainless steel with No. 4 finish.

C. Grease Duct Installation:

1. Duct-to-hood connection:

   a. Provide joints with continuous internal or external liquid-tight welded or brazed joints. Joints shall be smooth, without grease traps.
   b. For hoods with duct collar, provide 1-inch deep welded flange connection made with 1”x1” angle iron welded to the full perimeter of the duct, not less than 1” above the bottom end of the duct. Provide gasket rated for 1500°F minimum. Secure with stud bolts not less than ¼-inch in diameter welded to the hood, with 4” spacing on-center.

2. Duct-to-fan connection: Provide flanged and gasketed connection at the base of the fan for vertical discharge fans, or flanged, gasketed, and bolted for in-line fans. Gasket and sealing materials shall be rated for continuous duty at a minimum of 1500°F.
3. Light test: Prior to concealment of any portion of a grease duct system, a leakage test shall be performed. A light with a power rating of 100W shall be passed through the entire section of ductwork to be tested, including duct-to-hood connection.
4. Hangers and Supports: Bolts, screws, and fasteners shall not penetrate duct walls.
5. Clearances: Install ductwork with a clearance to combustibles in accordance with ASTM E 2336 and rated duct wrap.
6. Slope: All horizontal grease duct shall be sloped toward the hood or grease reservoir at a rate of ¼ inch per foot. Where horizontal runs exceed 75 feet, slope shall be 1” per foot.

7. Reservoirs: Locate grease reservoirs where duct cannot slope to hood. Locate on bottom of duct, full width, and 12” long, with a depth of 1”, with a sloping bottom to duct drain. Provide cleanout on side of duct to clean and inspect reservoir.

D. Cleanout access doors:

1. Provide access doors in the following locations:

a. Sections of grease duct that are inaccessible from the hood or discharge opening.
b. Spaced not more than 20’ apart.
c. Within 10’ of changes in direction greater than 45°.

2. Install cleanout access doors per manufacturer’s instructions.

3.06 INSTALLATION OF FLEXIBLE DUCTS

A. Maximum Length: For any duct run using flexible ductwork, do not exceed 8' - 0" extended length or as required by local authorities.

B. Installation: Install in accordance with Section III of SMACNA's, "HVAC Duct Construction Standards, Metal and Flexible".

3.07 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 function.

B. Install turning vanes in square or rectangular 90-degree elbows in supply, return and exhaust air systems, and elsewhere as indicated.

C. Install 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.

D. Install access doors for the following:

1. Access to dampers.
2. Access to fire dampers and smoke-fire dampers (one on each side of damper) in duct.
3. Access to heating coils (one on each side of coil) in duct.
4. Access to control devices.

3.08 INSTALLATION OF FIRE DAMPERS

A. Install fire dampers per the manufacturer’s installation instructions and in accordance with the current edition of UL-555 Standard for Fire Dampers.

B. Fire Damper Identification: Access points, i.e. access doors, access panels, lay-in ceiling tile, etc., shall be permanently identified on the exterior of the access point by a label having letters not less than 0.5” in height reading “FIRE DAMPER”.

3.09 INSTALLATION OF FIRE/SMOKE DAMPERS

A. Install fire/smoke dampers per the manufacturer’s installation instructions and in accordance with the current edition of UL-555 Standard for Fire Dampers and UL-555S Standard for Leakage Rated Dampers for Use in Smoke Control Systems.

B. Fire/Smoke Damper Identification: Access points, i.e. access doors, access panels, lay-in ceiling tile, etc., shall be permanently identified on the exterior of the access point by a label having letters not less than 0.5” in height reading “FIRE/SMOKE DAMPER”.

3.10 INSTALLATION OF GRILLES, REGISTERS, AND DIFFUSERS

A. General: Install grilles, registers and diffusers in accordance with manufacturer's written instructions and in accordance with recognized industry practices to ensure that products serve intended functions.

B. Locate ceiling grilles, registers and diffusers, as indicated on general construction "Reflected Ceiling Plans".

C. Provide code approved support for grilles, registers and diffusers in lay-in ceilings.

3.11 INSTALLATION OF HIGH-VOLUME LOW SPEED (HVLS) FANS

A. Install units per manufacturer's written instructions.

B. All safety and support features must be installed. These include guy wires and safety cables as well as airfoil retainer locking features.

C. Adjust unit as required for proper operation in accordance with manufacturer’s installation instructions.

D. Securely anchor units.

E. Ensure that operating parts turn freely prior to initial startup.

F. Repair or replace damaged parts, dents, buckles, abrasions or other damage affecting appearance or serviceability, as acceptable to Architect.

G. Install network controller, network CAT5 wiring system and all required network repeaters/isolators for a complete control system in accordance with the manufacturers control system installation requirements.

H. Coordinate fan mounting and support kit with structural roof framing. Provide mounting type compatible with the roof structure.

I. Provide extension arms and any applicable guy wires as required to meet manufacturers required clearance to bottom of structure or bottom of ceiling. Provide minimum clearance to overhead structure and overhead ceiling per manufacturer’s requirements.

J. Where ceiling fan extension arm penetrates a ceiling, provide penetration with an escutcheon.

K. Fire protection contractor to provide (4) fire sprinkler heads centered around fan and located a minimum of 3’ above fan. Coordinate fan mounting and sprinkler head arrangement with the fire protection contractor to meet these requirements from the NFPA.

L. Fire alarm / fire sprinkler contractor to interface a fire alarm shutdown to each HVLS fan upon detection of a waterflow signal from the alarm system in accordance with NFPA 72.

3.12 INSTALLATION OF FANS

A. General: Install fans where indicated, in accordance with manufacturer's installation instructions, and with recognized industry practices, to ensure that fans comply with requirements and serve intended purposes.

B. 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. Ensure that rotation is in direction indicated and intended for proper performance. Do not proceed with fan start-up until wiring installation is acceptable to fan Installer.

3.13 INSTALLATION OF AIR TERMINAL UNITS

A. General: Install air terminal units 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.

3.14 INSTALLATION OF DIRECT VENT SYSTEMS FOR CONDENSING APPLIANCES

A. General: Provide a fully sealed combustion vent system consisting of pipe/duct sections, fittings and accessories that meet the requirements of the vented appliance and vent manufacturer. These systems shall include, but are not limited to: all positive pressure, condensing, direct vented appliances (Category IV).

B. Flue: Provide flue materials as indicated on the mechanical plans and per the appliance manufacturer’s installation instructions. Materials for flue piping where indicated on the mechanical drawings shall not be substituted, unless approval is granted by the engineer prior to bid. PVC flue piping or foam core piping shall not be used for any flue piping system. If materials specified on the drawings do not comply with the manufacturer’s instructions, submit a request for clarification to the engineer.

C. Combustion Air: Provide combustion air materials as required by the appliance manufacturer based on the anticipating routing. Insulate per Section 23 0700 to prevent condensation from forming on the exterior of the pipe/duct.

D. Accessories: Provide all accessories, as required by the manufacturer, for a complete venting system.

E. Installation:

1. Install flue piping per the manufacturer's installation instructions. All horizontal flue piping to slope toward appliance at a minimum of ¼" per foot.
2. Provide drains as required at bottom of any vertical rises that are not drained back toward appliance. Provide a trap in each flue piping drain to prevent flue gas exfiltration through the drain piping.
3. Provide all required supports and hangers per the manufacturer's requirements.

3.15 EQUIPMENT CONNECTIONS

A. General: Connect metal ductwork to equipment as indicated, provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery. Provide access doors as indicated.

3.16 ADJUSTING AND CLEANING

A. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration. Clean existing ductwork to be reused.

B. Strip protective paper from stainless 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, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

D. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.

3.17 EXTRA STOCK

A. Provide one complete extra set of filters for each air handling system. If system is designed to include pre-filters and after- filters, provide only pre-filters. Install new filters at completion of air handling system work, and prior to testing, adjusting, and balancing work. Obtain receipt from Owner that new filters have been installed.

3.18 SPARE PARTS

A. Furnish to Owner, with receipt, 3 operating keys for each type of air outlet and inlet that require them.

B. Furnish to Owner, with receipt, one spare set of belts for each belt driven centrifugal fan.

C. Furnish to Owner, with receipt, one set of filters for each unit requiring filters.

3.19 TRAINING OF OWNER'S PERSONNEL

A. Provide services of manufacturer's technical representative **for 1/2 day** to instruct Owner's personnel in operation and maintenance of heating and cooling units.

1. Schedule training with Owner, provide at least 7-day notice to Contractor and Engineer of training date.

END OF SECTION 233000

SECTION 235200 - HEAT GENERATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Refer to Section 230500: Common Work Results for HVAC.

1.02 DESCRIPTION OF WORK

A. Types of boilers and accessories specified in this section include the following:

1. High efficiency wall hung boiler.

B. Electrical Work: Provide the following wiring as work of this section, in accordance with requirements of Division 26:

1. Mechanical contractor to verify Division 26 contractor is aware of ASME-CSD requirement for remote disconnect switches for boiler burner power. Refer to Electrical Wiring and Safety Device Work and Materials Responsibilities in Specification Section 230500.
2. Provide control wiring between boiler control panel and thermostats, aquastats, pressurestats, or any other control device.
3. Provide factory-mounted and wired controls and electrical devices as specified in this section.

C. CSD-1 Compliance:

1. As a minimum, all automatically fired boilers shall be provided with controls and safety devices in accordance with ANSI/ASME CSD-1. Other more stringent condition may be required by the individual boiler specifications and information provided on the Drawings. Contractor shall meet all requirements.

PART 2 - PRODUCTS

2.01 HIGH EFFICIENCY WALL HUNG BOILER

A. General Requirements:

1. Furnish and install completely assembled, modulating, sealed combustion, high efficiency, gas-fired boiler(s) with a stainless steel, fire tube heat exchanger.
2. Installation of the boiler(s) shall be according to manufacturer’s installation instructions and all work shall be completed in a neat and workmanship like manner.
3. Fuel source shall be natural gas.

4. The boiler(s) shall operate at a minimum Annual Fuel Utilization Efficiency of 95% and shall comply with the energy efficiency requirements of ASHRAE 90.1, latest edition and the minimum efficiency requirements of ASHRAE 103, latest edition.
5. The boiler(s) AFUE efficiency shall be verified through a third-party testing agency under the guidance of the Hydronics Institute Division of AHRI and listed in the AHRI Certification Directory.
6. The boiler(s) shall be capable of full modulation, with a turn down of 4 to 1
7. The boiler(s) shall be manufactured by an ISO 9001 registered company and shall bear the ASME "H" stamp according to Section IV of the ASME Boiler and Pressure Vessel Code.

    a. The stainless-steel heat exchanger of the boiler(s) is to be hydrostatically pressure tested at the factory in accordance with ASME requirements.
    b. The maximum allowable working pressure is 30 psig water as listed on the rating plate.
    c. The heat exchanger shall be registered with the National Board and contain a registry number on the rating plate.

8. The boiler(s) shall meet the following regulatory requirements:

    a. The boiler(s) shall be ITS / ETL certified and listed to ANSI Z21.13/CSA 4.9 test standards for US and Canada.
    b. Boiler(s) shall meet or exceed the SCAQMD (South Coast Air Quality Management District of California) Low NOx emission requirement of 14 NG/J.
    c. The boiler(s) shall meet Department of Energy guidelines for Energy Star energy efficiency.

B. Product Specifications:

1. Boiler Construction

    a. Stainless steel, fire tube heat exchanger
    b. The grade of stainless must be of 439 providing resistance to corrosion at elevated temperatures.
    c. The heat exchanger shall be of welded construction and shall not contain any banding materials, bolts, gaskets or O-rings in the construction.
    d. The boiler combustion chamber shall be sealed and located at the top of the heat exchanger which should be of a counterflow design and vertical to assure that sediment and any potential lime that may form will fall to the bottom away from the tube sheet.
    e. The boiler(s) flue ways shall be of a vertical design that allows condensate to "wash down" the flue surface preventing potential combustion residue from adhering to the flue ways.
    f. The boiler(s) shall be supplied with a gas valve designed with negative pressure regulation.
    g. The gas valve on the boiler(s) shall operate with an inlet gas pressure of a minimum 5" w.c to a maximum of 13" w.c and shall be independent of the type of gas (natural or liquefied propane).
    h. The burner shall be a premix combustion type system, made with a burner head constructed of stainless material and able to provide a wide range of modulating firing rates.

i. The boiler(s) shall be equipped with a variable speed blower system to precisely control the fuel/air mixture to provide modulating boiler firing rates for maximum efficiency.
j. The boiler(s) shall be constructed with a heavy gauge steel jacket assembly, primed and prepainted
k. The individual boiler control shall have an electronic display for boiler set-up, boiler status and boiler diagnostics.

2. Boiler Controls and Trim

a. All electrical components shall be of the highest quality manufacture and bear a UL or UL recognized label.
b. Controller shall have an electronic display for boiler set-up, boiler status, and boiler diagnostic. All components shall be easily accessed and serviceable from the front and top of the unit.
c. Supply voltage shall be 120 volt / 60 hertz / single phase on both sides.
d. The boiler(s) shall be furnished with controls and boiler trim that provides:

1) High limit temperature control of 200°F
2) Operating temperature limit of 60°F to 194°F
3) Temperature/pressure gauge dial that is clearly marked and easy to read.
4) ASME certified pressure relief valve, set to relieve at 30 psig.
5) Flue gas, outlet water temperature and return water temperature sensors
6) Low water protection
7) Built-in freeze protection
8) Grundfos flanged circulator, 3-speed adjustment with toggle control.
9) Outdoor sensor to provide Outdoor Reset Control
10) Domestic priority with ability to reset the boiler operating temperature
11) Allows a 0-10 VDC input signal to allow external BMS control

3. Venting and Combustion Air

a. The boiler shall be installed and vented with **Direct Vent Sidewall system / Direct Vent Vertical system / Direct Vent Vertical with Sidewall Air system / Sidewall Vent with Room Air system / Vertical Vent with Room Air system**.

C. Warranty

1. The boiler heat exchanger shall carry a ten (10) year limited warranty.
2. The parts used in the assembly of the boiler shall carry a one (1) year warranty.

D. Acceptable Manufacturers:

1. Triangle Tube “Prestige”.
2. Lochinvar “Knight”.
3. Buderus
4. Alternate manufacturers to submit for approval.

2.02 SAFETY AND RELIEF VALVES

A. Steam Safety Valves: Provide steam safety valves as indicated, of size and capacity as selected by Installer for proper relieving capacity, constructed in accordance with ASME Boiler and Pressure Vessel Code:

1. Bronze Safety Valves: Construct housing of cast bronze, disc and nozzle of forged copper alloy, lap seats to optical flatness. Set valve to relieve at 10 PSI above operating pressure.
2. Cast-Iron Safety Valves: Construct of cast iron, with all bronze/brass trim, and fully enclosed spring. Set valve to relieve at 10 PSI above operating pressure.
3. Drip Pan Elbows: Provide drip pan elbows on steam safety valves required to discharge to outdoors. Construct of cast iron, with bottom drain and pan drain connections.
4. Exhaust Heads: Provide exhaust heads on exhaust steam lines, constructed of cast iron, and consisting of helico-centrifugal chamber and drain.
5. Acceptable Manufacturers:

    a. Kunkle Valve Co., Inc.
    b. Lunkenheimer (The) Co., Div. of Conval Corp.
    c. Spirax Sarco, Inc.
    d. Watts Regulator Co.

B. Water Relief Valves: Provide water relief valves as indicated, of size and capacity as selected by Installer for proper relieving capacity, constructed in accordance with ASME Boiler and Pressure Vessel Code:

1. Pressure Relief Valves: Construct of bronze body, metallic disc, metal seat, with nonmechanically guided stem. Set valve to relieve at 10 PSI above operating pressure.
2. Acceptable Manufacturers:

    a. Amtrol, Inc.
    b. Bell & Gossett ITT.
    c. Spirax Sarco Co.
    d. Watts Regulator Co.

2.03 BOILER FLUE AND CONDENSING BOILER ACCESSORIES

A. Provide either JJM Boiler Works #JM Series or Axiom #NC-1 Condenser Neutralization Tube and Piping for condensing flues and combustion chambers. Pipe to nearest drain.

PART 3 - EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which boilers are to be installed, and substrate which will support boilers. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF BOILERS

A. General: Install boilers in accordance with manufacturer's installation instructions, in accordance with State and local code requirements, and in accordance with requirements of local Utility Company. Install units plumb and level, to tolerance of 1/8" in 10' - 0" in both directions. Maintain manufacturer's recommended clearances around and over boilers.

B. Support: Install boilers on 4" thick concrete pad, 4" larger on each side than base of unit.

C. Erection: Assemble boiler sections in proper sequence and with sealing between each section. Assemble boiler trim shipped loose, or unassembled for shipment purposes. Follow manufacturer's installation instructions.

D. Electrical Work: 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 work installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections. Do not proceed with equipment start-up until electrical work is acceptable to equipment Installer.

E. Venting: Verify venting requirements for pressure regulating valves in factory installed or factory supplied valve trains. Extend atmospheric vent to outdoors, full size of vent outlet when equipment is controlled by spark ignition. When equipment has standing pilot, pipe regulator vent(s) to combustion chamber. Verify regulator venting requirements with local authority prior to installation.

F. Provide neutralization kit and piping to nearest drain for condensing flues and combustion chambers.

3.03 BOILER START-UP AND TEST REQUIREMENTS

A. At a time requested by the Installing Contractor, the boiler representative shall adjust and start boiler. Copies of the starting report shall be sent to the Architect/Engineer prior to final inspection and shall include the following information for each boiler:

1. Temperature and pressure settings of the boiler.
2. Heating system water pressures, cold and hot.
3. Gas pressure setting.
4. Gas volume being burned.
5. Percent CO(2) and CO.

B. A component and integrated check shall be made of all controls. Factory tests do not substitute for this test. A foreman or superintendent of the Installing Division-23 Contractor familiar with the system shall also be present and witness this test.

C. Thermal efficiency shall be 80% minimum with CO(2) at a 9% minimum. Presence of CO in flue gas or high stack temperature will require corrective action by the Contractor.

D. Contractor shall request and obtain inspection and written approval of the installation by the State Division of Labor prior to building occupancy.

3.04 SAFETY AND RELIEF VALVES

A. Steam Safety Valves: Install as indicated on top of boilers. Pipe discharge to floor drain for low-pressure service. Pipe discharge to outdoors for high-pressure service, pipe drain outlets of drip pan elbow to floor drain. Pipe drain outlets of exhaust heads full size to floor drain or sewer.

B. Water Relief Valves: Install as indicated on top of boilers. Pipe discharge to floor drain.

3.05 CLOSE OUT PROCEDURES

A. Provide services of manufacturer's technical representative for one 8-hour day to instruct owner's personnel in operation and maintenance of the heat generation equipment.

END OF SECTION 235200

SECTION 235500 - FUEL FIRED HEATERS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Types of equipment specified in this Section include the following:

1. Gas-Fired Radiant Heaters.
2. Gas-Fired Unit Heaters

PART 2 - PRODUCTS

2.01 GAS FIRED RADIANT HEATERS (LOW INTENSITY, VACUUM TYPE)

A. Provide a vacuum type, gas fired, low intensity radiant heating system as indicated of type and capacity on the drawing scheduled and specified herein. The system shall employ the proper number of firing coils as indicated by the heat requirements of the area, as determined in accordance with procedures recommended by the manufacturer. All system components must be design-certified by the American Gas Association under American National Standard Z83.6

B. Vacuum Firing Burner Control: Each burner shall employ a heavy-duty cast-iron burner head with a lifetime warranty. A self-checking vacuum proving switch shall be located in each burner unit to prevent activation on loss of vacuum. The combustion chamber shall be isolated from the control compartment to prevent combustion air from being drawn across the controls. Ignition system (DSI) Direct Spark Igniter with flame rectification system. A three try, 15 second trial for ignition then lockout type control. Indicator lights shall be located on the bottom of burner cabinet to indicate “Power On” and “Burner On.” A sight glass shall be located on the side of the burner cabinet for visual flame inspection.

C. Combustion Pipe: The combustion pipe shall be 14-gauge aluminum steel for a minimum distance of 10 feet.

D. Radiant Pipe: The radiant pipe shall be 14-gauge black mild steel beginning at the end of the combustion pipe to the vacuum fan at the end of the unit. Couplings necessary to join pipes shall be a two-bolt draw band type.

E. Reflectors: The reflectors shall be of 22-gauge type 430 polished stainless steel. Reflectors shall be supported by means of the hanger bracket which will surround the reflector. The reflectors will bolt to this bracket at every other joint to allow for expansion.

F. Zone Control Panels: Infrared zone control panel shall be capable of controlling 2 zones. Sensing Device: Shall be a Black Bulb Sensor which will sense the mean radiant and air temperature in the conditioned space. Each zone shall have separate adjustment for setting the day and night temperatures. The range for the day setting shall be 32°F - 86°F. The range for the night setting shall be 23°F - 59°F. Each zone shall be capable of operating independently of

the others in one of the following modes: Off, day setting, night setting, day/night automatic. Each zone shall have indicator lights for power on and burners on. Provide separate zones for each ice sheet.

G. Warranty: Heaters are protected by a five-year warranty against defective materials or workmanship of the heat exchangers, reflectors, fan housings, burner heads, and burner/control housings. All purchased controls and components are protected by a twelve (12) month warranty. Any component that fails due to defective materials or workmanship during normal operation within this period will be repaired or replaced, free of charge, provided that the defective part is returned, freight paid, to the Indianapolis plant. Installations in corrosive environments must be made in accordance with factory-recommended procedures to be covered under this warranty. Notification of the defective part must be made in writing within the warranty period, which begins on the date of shipment.

H. Acceptable Manufacturers:

1. Superior Radiant Products.
2. Detroit Radiant Products.
3. AMBI-RAD.

2.02 GAS-FIRED UNIT HEATERS

A. General: Provide gas-fired unit heaters as indicated, of type and minimum capacity as scheduled, and as specified herein.

B. Construct Casing of galvanized steel, with baked enamel finish. Provide integral inserts for hanger rods.

1. Provide air diffusion louvers mounted on face of unit.

C. Construct heat exchanger of welded aluminized, or stainless steel. Provide draft diverter or collector box and integral power exhauster as required, construct integral to each heat exchanger section. Provide oval or round flue collar.

D. Construct burner of same material as heat exchanger, and include integral burner crossover. Design burner to be suitable for propane or natural gas.

E. Construct fan of aluminum, direct drive propeller type, and factory-balance.

PART 3 - EXECUTION

3.01 INSPECTION

A. General: Examine areas and conditions under which ductwork accessories and equipment are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF LOW INTENSITY GAS FIRED RADIANT HEATERS

A. General: Install units in accordance with the manufacturer's installation instructions.

B. Installing contractor shall verify conditions prior to installation. If there appears to be any combustible items within the infrared heater manufacturer's clearance requirements, whether it be building elements, equipment or storage items, the installing contractor shall notify the general contractor and engineer prior to installation so the installation can be revised to meet the clearance requirements.

C. Hang units from substrate using threaded rods and building attachments. Secure rods to unit hanger attachment. Adjust hangers to unit is plumb and heat is delivered perpendicular to the slope at the area to be heated.

D. Extended gas piping to within 5' from unit, provide drop with manual gas shutoff valve, 1/8" NPT plugged test connection, tee, and drip pocket. Locate piping drop so as to not interfere with service of unit. Extend gas piping runout, full size of gas train inlet, from tee to gas train connection, provide union with sufficient clearance for unit removal and service.

E. Install flue and combustion air piping up through roof or side wall and with flue and duct size and maximum lengths in accordance with manufacturer's installation instructions.

F. Extend power wiring from fused disconnect to electrical junction box on unit. Install thermostat in indicated location and per manufacturer's recommendations where thermostat will properly sense heat and not directly below unit. Provide low voltage wiring from thermostat to electrical junction box on unit. Comply with requirements of Division 26 for wiring.

3.03 INSTALLATION OF UNIT HEATERS

A. General: Install unit heaters as indicated, and in accordance with manufacturer's published installation instructions.

B. Hang units from substrate using threaded rods and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is plumb and level.

C. Extend gas piping to within 5' from unit, provide drop with manual gas shutoff valve, 1/8" NPT plugged test connection, tee, and drip pocket. Locate piping drop so as to not interfere with service of unit. Extend gas piping runout, full size of gas train inlet, from tee to gas train connection, provide union with sufficient clearance for unit removal and service.

D. Extend power wiring from fused disconnect to electrical junction box on unit. Install thermostat in indicated location, provide low voltage wiring from thermostat to electrical junction box on unit. Comply with requirements of Division 26 for wiring.

3.04 START-UP OF FUEL FIRED HEATERS

A. Start-up, test, and adjust fuel-fired heaters in accordance with manufacturer's published start-up instructions. Adjust air diffusion louvers for proper air flow. Verify proper line and manifold gas pressure. Check and calibrate controls, adjust burner for maximum efficiency.

END OF SECTION 235500

SECTION 237302 – PACKAGED ROOFTOP AIR HANDLING UNITS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Types of equipment specified in this section include the following:

1. Rooftop Heating & Cooling Units.

1.02 SPECIAL PROJECT WARRANTY

A. Warranty on Compressor and Heat Exchanger: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, compressors and/or heat exchangers with inadequate and defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement is limited to component replacement only, and does not include labor for removal and reinstallation.

1. Warranty Period: 5 years from date of substantial completion.

1.03 TEST AND BALANCE COORDINATION

A. Prior to starting work, the contract documents shall be given to the Test and Balance contractor for his review. If there are any areas of the air distribution system that cannot be balanced, due to the configuration of the system, a Request for Clarification shall be made in a timely manner to allow revisions to the documents before the systems are installed.

PART 2 - PRODUCTS

2.01 ROOFTOP UNITS (SMALL COMMERCIAL)

A. General: Provide factory-assembled and tested rooftop units as indicated, designed for roof or slab mounting, consisting of compressors, condensers, evaporator coils, condenser fans, supply fans, exhaust fans, refrigeration and temperature controls, filters, and dampers. Provide capacities and electrical characteristics as scheduled.

B. Casing: Provide manufacturer's standard casing construction, corrosion protection coating, and exterior finish. Provide removable panels and/or access doors for inspection and access to internal parts. Insulate casing with 1" thick minimum thermal insulation. Provide knockouts for electrical and piping connections. Provide condensate drain connection.

C. Evaporator Fans: Provide forward-curved, centrifugal, belt- driven fans with adjustable sheaves or direct-driven fans; and permanently lubricated motor bearings.

D. Condenser Fans: Provide propeller-type, direct-driven fans with permanently lubricated bearings.

E. Coils: For evaporator and condenser, provide non-ferrous construction with aluminum plate fins mechanically bonded to seamless copper tubes; with brazed tubing joints.

F. Compressors: Provide serviceable, semi-hermetic, or fully hermetic compressors, in accordance with manufacturer's published technical data. Provide vibration isolators and crankcase heaters. Provide hot-gas bypass valve and piping on one compressor for variable air volume systems.

G. Safety Controls: Provide the following controls, each designed for manual reset:

1. Low pressure cutout.
2. High pressure cutout.
3. Compressor motor overload protection.

H. Heat Exchangers: Provide manufacturer's **standard construction / aluminized steel / stainless steel** for gas-fired heat exchangers and burners.

1. Controls: Provide the following controls:

a. Redundant gas valve.
b. Intermittent pilot ignition.
c. Electronic spark ignition system.
d. High limit cutout.
e. Forced draft proving switch.

I. Economizer Control: Provide economizer control consisting of return and outside air dampers, outside air filter, fully modulating electric control system with dry bulb control, and adjustable mixed-air thermostat. Design system for 100% outside air capability. Provide automatic changeover through adjustable economizer control device.

J. Variable Air Volume Control: Provide VAV control consisting of discharge air step controller, and duct static pressure controller.

K. Accessories: Provide the following accessories as indicated and/ or scheduled:

1. Curb: Provide insulated roof curb under unit, constructed in accordance with NRCA Standards. Provide seal strip between curb and unit, and wood nailer for flashing. For deck slopes, fabricate support units to form level top edge.
2. Hail Guards: Provide manufacturer’s coil guards for condenser coil protection.

L. Acceptable Manufacturers:

1. Carrier Air Conditioning; Div. of Carrier Corp.
2. Trane Co.
3. Aaon, Inc.
4. McQuay International.

2.02 ROOFTOP UNITS (LARGE COMMERCIAL)

A. General: Provide factory-assembled and tested rooftop units as indicated, designed for roof mounting, consisting of compressors, condensers, evaporator coils, condenser and evaporator fans, refrigeration and temperature controls, filters, and dampers. Provide capacities and electrical characteristics as scheduled.

B. Casing: Provide manufacturer's standard casing construction, corrosion protection coating, and exterior finish. Provide removable panels and/or access doors for inspection and access to internal parts. Insulate casing with 1" thick minimum thermal insulation. Provide knockouts for electrical and piping connections. Provide condensate drain connection, and lifting lugs.

C. Supply/Exhaust Fans: Provide **forward curved or airfoil**, centrifugal, belt-driven fans with adjustable sheaves; permanently lubricated motor bearings and spring isolators. Provide **VFDs on VAV supply fans and VFDs on exhaust fans for building pressure control**.

D. Condenser Fans: Provide propeller-type, direct-driven fans with permanently lubricated bearings.

E. Coils: For evaporator and condenser, provide non-ferrous construction with aluminum plate fins mechanically bonded to seamless copper tubes; with brazed tubing joints.

1. Circuit evaporator to provide full active face on minimum cooling step.

F. Compressors: Provide serviceable, semi-hermetic, or hermetic compressors. Provide vibration isolators, and crankcase heaters if required which de-energize during compressor operation.

1. Provide cylinder unloaders or compressor cycling for capacity control, with minimum steps as scheduled.
2. Provide hot-gas bypass valve and piping on one compressor for variable air volume systems.
3. Provide thermal expansion valves, filter dryers, sight glasses, compressor service valves, liquid line service valves; and provide minimum of 2 refrigerant circuits for units having 2 or more compressors. **Provide fan-cycling control for low ambient control to 35°F, 0°F.**

G. Safety Controls: Provide the following controls:

1. Low pressure cutout, manual reset.
2. High pressure cutout, manual reset.
3. Compressor motor overload protection, manual reset.
4. Anti-recycling timing device.
5. Adjustable low-ambient lockout.
6. See Section 230923 “Temperature Controls – DDC” for additional controls. Coordinate with temperature control contractor. ***Standard rooftop manufacturer control sequences may not be acceptable***.

H. Heat Exchangers: Provide **aluminized steel /stainless steel** construction for gas-fired heat exchangers and burners, designed for minimum of **2-stage operation / 4:1 turndown ratio with modulating gas valve**. Provide single gas connection.

1. Controls: Provide the following controls:

    a. Redundant gas valves.
    b. Intermittent pilot ignition.
    c. Electronic spark ignition system.
    d. High limit cutout.
    e. Forced draft proving switch.
    f. Flame roll-out switch.

I. Economizer Control: Provide economizer control consisting of return and outside air dampers, fully modulating control system with dry bulb control, and adjustable mixed-air thermostat. Design system for 100% outside air capability.

J. Variable Air Volume Control: Provide inlet vanes / variable frequency drives.

K. Provide control strategy on OSA damper to maintain minimum OSA under all air flow conditions. **Refer to Temperature Control documents.**

L. Filters: Provide filter section consisting of 2" thick, 30% efficient fiberglass throwaway filters in filter rack, with maximum face velocity of 300 fpm.

M. Electrical: Provide 115V convenience outlet, separately fused, for unit service. Provide means for unit power connection either through unit cabinet or within roof curb perimeter.

N. Sequence of Operation: ***Factory supplied sequences of operation may not be acceptable.*** Sequences must be as specified in the Temperature Controls Section 230923 and provided by the rooftop unit manufacturer.

O. Temperature Control: Provide factory-installed, demand-oriented solid-state control system with minimum of 2 cooling steps and 2 heating steps. Provide solid-state thermostats with dead-band, and sub-base with system and fan switches.

    1. Provide discharge temperature reset capability with space temperature override.
    2. Provide 7-day programmable time clock, with power failure carryover, for remote mounting.
    3. Provide warm-up cycle.

P. Accessories: Provide the following accessories as indicated and/ or scheduled:

    1. Curb: Provide insulated roof curb under unit, constructed in accordance with NRCA Standards. Provide seal strip between curb and unit, and wood nailer for flashing. For sloping decks, fabricate support units to form level top edge.
    2. Remote Control Panel: Furnish panel for remote mounting containing control of heating, cooling, evaporator fan, and outdoor damper; and indicator lights for up to 6-unit functions.
    3. Anti-Recycling Control: Provide control to automatically prevent compressor restart for 5-minutes after shutdown.
    4. Hail Guards: Provide manufacturer’s factory installed coil guards for condenser coil protection.
    5. Motors: Provide premium efficiency motors when used with variable frequency drives.

Q. Space Sensors

1. Provide room space sensors with override button only. No display or setpoint adjustment should be provided. All setpoint control shall be through the BAS.
2. Provide space thermostat with LCD display, push-button setpoint adjustment, and override button. Thermostat shall be capable of staged heating and cooling with automatic changeover.

R. Acceptable Manufacturers:

1. Carrier Air Conditioning; Div. of Carrier Corp.
2. Trane Co.
3. Johnson Controls - Factory Direct (previously York International).
4. Aaon Inc.
5. McQuay International.

PART 3 - EXECUTION

3.01 INSPECTION

A. General: Examine areas and conditions under which ductwork accessories and equipment are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF ROOFTOP UNITS

A. General: Install rooftop units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

B. Support: Install units on roof curb, in accordance with National Roofing Contractors Association (NRCA) installation recommendations.

C. 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.

D. Start-up rooftop units, in accordance with manufacturer's start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

E. Grounding:

1. Provide positive equipment ground for rooftop unit components.

3.03 EXTRA STOCK

A. Provide one complete extra set of filters for each air handling system. If system is designed to include pre-filters and after- filters, provide only pre-filters. Install new filters at completion of air handling system work, and prior to testing, adjusting, and balancing work. Obtain receipt from Owner that new filters have been installed.

3.04 FIELD QUALITY CONTROL

A. Upon completion of installation of equipment and after motor has been energized with normal power source, test equipment to demonstrate compliance with requirements. Where possible, field correct malfunctioning equipment, then retest to demonstrate compliance. Replace equipment which cannot be satisfactorily corrected.

3.05 EQUIPMENT CONNECTIONS

A. General: Connect metal ductwork to equipment as indicated, provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery. Provide access doors as indicated.

3.06 ADJUSTING AND CLEANING

A. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration. Clean existing ductwork to be reused.

3.07 SPARE PARTS

A. Furnish to Owner, with receipt, one spare set of belts for each belt driven centrifugal fan.

B. Furnish to Owner, with receipt, one set of filters for each unit requiring filters.

3.08 TRAINING OF OWNER’S PERSONNEL

A. Provide services of manufacturer's technical representative **for 1/2 day** to instruct Owner's personnel in operation and maintenance of heating and cooling units.

1. Schedule training with Owner, provide at least 7-day notice to Contractor and Engineer of training date.

END OF SECTION 237302

SECTION 260500 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL:

1.1 RELATED DOCUMENTS:

A. All drawings and specifications associated with the entire project, including the General Conditions of the Contract for Construction, General and Supplementary Conditions, and Division-01 specification sections shall apply to the Division 26 specifications and drawings. The Contractor shall be responsible for reviewing and becoming familiar with all Contract Documents associated with the project.

B. Where contradictions occur between this section and Division 1, the more stringent requirement shall apply.

1.2 SUMMARY:

A. Section Includes:

1. Electrical equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Sleeve seals.
4. Common electrical installation requirements.

B. SUBMITTALS

1. Product Data: For sleeve seals.

C. PROJECT SEISMIC REQUIREMENTS:

1. All systems shall be installed to meet NFPA and IBC Seismic requirements.

a. Where any conflicts arise the more stringent requirements shall be applicable.
b. The design of the seismic requirements shall be the responsibility of the contractor.

2. Installation shall comply with the local seismic requirements for the area of installation. Provide restraints, bracing, anchors, vibration isolation, seismic snubbers, and all other components required for the installation.

1.3 ELECTRICAL INSTALLATIONS:

A. Drawings are diagrammatic in character and do not necessarily indicate every required conduit, box, fitting, etc.

B. Drawings and specifications are complementary. Whatever is called for in either is binding as though called for in both. Report any discrepancies to the Engineer and obtain written instructions before proceeding. Where any contradictions occur between the specifications and the drawings the more stringent requirement shall apply. The contractor shall include pricing for the more stringent and expensive requirements.

C. Before any work is begun, determine that equipment will properly fit the space and that conduit can be run as contemplated without interferences between systems, with structural elements or with the work of other trades.

A. Verify all dimensions by field measurements.

D. Where mounting heights are not detailed or dimensioned, install electrical conduits, boxes, and overhead equipment to provide the maximum headroom possible. In general, keep installations tight to structure.

E. Make allowance for building expansion and contraction as it relates to all building electrical components and conduit systems that are subject to such.

F. The ceiling space shall not be layered. It is the contractor's responsibility to offset and coordinate any systems as required to allow installation within the identified ceiling cavity. The contractor shall include labor and material in the base bid to accommodate such offsets. All conduit systems shall be routed as high as possible. Keep all equipment in accessible areas and coordinate with systems and equipment from other sections.

G. Develop and complete routing strategies which will allow fully coordinated system to be installed in a fully functional manner. The Engineers contract drawings shall be for system design intent and general configurations.

1.4 ACCESSIBILITY:

A. Install equipment and materials to provide required code clearances and access for servicing and maintenance. Coordinate the final location with piping, ducts, and equipment of other trades to insure proper access for all trades. Coordinate locations of concealed equipment, disconnects, and boxes with access panels and doors. Allow ample space for removal of parts, fuses, lamps, etc. that require replacement or servicing.

B. Extend all conduits so that junction and pull boxes are in accessible locations.

C. Provide access panel or doors where equipment or boxes are concealed behind finished surfaces.

1.5 COORDINATION:

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To preserve headroom and keep openings and passageways clear, so all equipment is serviceable.
4. To allow right of way for piping and conduit installed at required slope.
5. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

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

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed.

D. Coordinate the cutting and patching of building components to accommodate the installation of electrical equipment and materials. Any cutting and patching made necessary by failure to provide measurements, drawings and layouts at the proper time shall be done at no additional cost in contract sum.

B. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

E. Coordinate the installation of electrical materials and equipment above and below ceilings with suspension system, luminaires and other building components. Ductwork and piping shall not be installed above electrical panelboards, switchboards, motor control centers, and transformers.

F. Coordinate ceiling cavity space carefully with all trades. In the event of conflict, install mechanical and electrical systems within the cavity space allocation in the following order of priority:

1. Equipment and required clearances
2. Plumbing waste, cooling coil drain piping and roof drain mains and leaders.
3. Ductwork mains
4. Plumbing vent piping
5. Low pressure ductwork and air devices.
6. Electrical and communication conduits, raceways and cable tray.
7. Domestic hot and cold water
8. Hydronic piping
9. Fire sprinkler mains, branch piping and drops (locate as tight to structure as possible).
10. DDC control wiring and other low voltage systems.
11. Fire alarm systems.

G. Utility Connections:

A. Coordinate connection of electrical systems with exterior utilities and services. Comply with requirements of governing regulations, franchised service companies and controlling agencies. Provide required connection for each service.

B. The contract documents indicate the available information on existing utilities and services and on new services (if any) to be provided to the project by utility companies and agencies. Notify Engineer immediately if discrepancies are found.

C. Coordinate electrical utility interruptions one week in advance with the Owner and the Utility Company. Plan work so that duration of the interruption is kept to a minimum.

1.6 DESIGN WORK REQUIRED BY CONTRACTOR:

A. Systems or subsystems which require design responsibility by the contractor include but are not limited to:

1. Final coordinated distribution systems within the ceiling cavity.
2. Any system not fully detailed
3. Fire alarm shop drawings
4. Equipment supports, hangers, anchors and seismic systems not fully detailed nor specified in these documents, or catalogued by the manufacturer.
5. Seismic restraint systems

1.7 PROJECT CONDITIONS:

A. The contractor shall be required to attend a pre-bid walk-thru if required and shall make themselves familiar with the existing conditions. No additional costs to the Owner shall be accepted for additional work for existing conditions.

B. Field verify all conditions prior to submitting bids.

C. Report any damaged equipment or systems to the Owner prior to any work.

D. Protect all work against theft, injury or damage from all causes until it has been tested and accepted.

E. Repair or replace any part of the work which may show defect during one year from the final acceptance of all work, provided such defect is, in the opinion of the Architect, due to imperfect material or workmanship and not due to the Owner's carelessness or improper use.

F. Coordinate all services shut-down with the Owner. Provide temporary services if work cannot be completed after hours. Coordinate any required disruptions with Owner one week in advance.

1.8 REQUIREMENTS OF REGULATORY AGENCIES:

A. Execute and inspect all work in accordance with Underwriters Laboratories (UL), and all local and state codes, rules and regulations applicable to the trade affected as a minimum, but if the plans and/or specifications call for requirements that exceed these rules and regulations, the more stringent requirement shall be followed. Follow application sections and requirements and testing procedures of Federal and State regulations, OSHA, NFPA, IEEE, NEMA, CBM, ANSI, NECA, ICEA and IETA.

B. All material used on this project shall be UL listed and labeled and be acceptable to the authority having jurisdiction as suitable for the use intended.

1.9 PERMITS AND FEES:

A. Owner or Contractor shall pay all fees required for connection to municipal and public utility facilities.

B. Contractor shall arrange for and pay for all inspections, licenses and certificates required in connection with the work.

1.10 TEMPORARY FACILITIES:

A. Light, Heat, Power, Etc.

1. Responsibility for providing temporary electricity, heat and other facilities shall be as identified in these specifications, as shown on the drawings and as specified in Division 1.

B. Building distribution equipment and devices shall not be used without written permission of the Owner. If used for temporary power, the equipment shall be properly maintained and any damage resulting from use shall be repaired by the Contractor. The guarantee period for new equipment shall not begin until the equipment is turned over to the Owner.

1.11 PRODUCT OPTIONS AND SUBSTITUTIONS:

A. The burden of proof that proposed equipment is equal in size, capacity, performance, and other pertinent criteria for this specific installation, or superior to that specified is up to the Contractor. Substituted equipment will only be allowed where specifically listed in a written addendum. If substitutions are not granted, the specified materials and equipment must be installed. Where substituted equipment is allowed, it shall be the Contractor's responsibility to notify all related trades of the accepted substitution and to assume full responsibility for all costs caused as a result of the substitution.

B. Unless otherwise specified, all materials and equipment shall be of domestic (USA) manufacture.

C. Where pre-printed data covers more than one distinct product, size, type, material, trim, accessory group or other variation, mark submitted copy with black pen to indicate which of the variations is to be provided.

1.12 ELECTRICAL SUBMITTALS:

A. General

1. Refer to the Conditions of the Contract (General and Supplementary) and Division 1 Section covering shop drawings, product data, and samples for submittal definitions, requirements, and procedures.

2. The submittals shall be submitted as a fully complete package identified by the specification section. The cover shall be identified with the job name, Owner's project number, date, Prime Contractor's name, etc. Submittals that are not complete with the required information will be sent back to be corrected.

3. An index shall be provided which includes:

a. Product
b. Plan Reference (if applicable)
c. Specification Section
d. Manufacturer and Model Number

4. Provide electronic submittals unless it is determined that hard copies are required.

5. Provide two full size (2) hard copy sets and electronic copy of fire alarm shop drawings, coordination drawings, O&M manuals, as-built documents and samples required for the project.

6. The Contractor shall identify any "long lead time" items which may impact the overall project schedule. If these submittal requirements affect the schedule, the Contractor shall identify the impacts and confer with the Engineer within two weeks of entering into the contract.

7. Submittals shall be provided for review within four (4) working weeks from award of contract to successful bidder.

C. The manufacturer's material or equipment listed first in the specifications or on the drawings are the types to be provided for the establishment of size, capacity, grade and quality. If alternates are used in lieu of the first names, the cost of any changes in construction required by their use shall be borne by this Contractor.

G. Before starting work, prepare and submit to the Architect/Engineer shop drawings and descriptive product data. Continue to submit in the stated format after each Architect/Engineer's action until a "No Exception Taken" or "Make Correction Noted" action is received with the exception of fire alarm submittals which must be submitted until a "NO EXCEPTION TAKEN" action is received. Submittals shall include the following specified materials and, in addition, any materials not listed below but which are specified in the individual sections of Division 16 which follow.

1. Raceways including surface raceways and wireways.
2. Wiring devices, including tele/data/power poles.
3. Electrical equipment signs and labels.
4. Switchboards
5. Grounding
6. Transformers
7. Panelboards
8. Disconnect Switches
9. Automatic transfer switches including all ancillary equipment.
10. Poles and Standards.
11. Lighting
12. Emergency power supplies (USP) including unit type equipment.
13. Engine generator including transfer switches and all ancillary equipment.
14. Fire alarm and detection system.

H. The Design Professional’s review and appropriate action on all submittals and shop drawings is only for the limited purpose of checking for conformance with the design concept and the information expressed in the contract documents. This review shall not include:

1. Accuracy or completeness of details, such as quantities, dimensions, weights or gauges, fabrication processes
2. Construction means or methods
3. Coordination of the work with other trades
4. Construction safety precautions

N. Mark submittals with designations as shown on the drawings and identify as required by Specification Sections. Identification shall contain the information as required in details and each label shall be submitted in list form with disconnects, MCC's, panelboards, switchboards, overcurrent protection devices and utilization equipment.

1.13 DELIVERY, STORAGE AND HANDLING:

A. Refer to the Division 1, Sections on Transportation and Handling and Storage and Protection.

B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.

C. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage and weather.

D. Coordinate deliveries of electrical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

1.14 TESTING:

A. Submit test reports as outlined in Division 1 Sections on Quality Control Services and each Division 26 Section.

B. Testing as required by these specifications shall pertain to all equipment, wiring, devices, etc. installed under this contract and being reused.

C. General Scope:

1. Perform all tests and operational checks to assure that all electrical equipment, both Contractor and Owner-supplied, is operational within industry and manufacturer's tolerances and is installed in accordance with design specifications.

2. The tests and operational checks shall determine the suitability for energization.

3. Schedule tests and give a minimum of two weeks advance notice to the Architect. Reschedule testing for Owner convenience if required.

D. Test Report: Submit three copies of the completed report to the Architect no later than fifteen (15) days after completion of test unless directed otherwise. The test report shall be bound and its contents certified.

The test report shall include the following:

1. Project information including: Building, name, address, date, and other pertinent information.

2. List of equipment tested.

3. Description of test.

4. List of test equipment used and calibration date.

5. Baseline, acceptable, or published target value for test with code or standard reference indicating where value was derived.

6. Test results that summarize all measured values with baseline values.

7. Conclusions and recommendations.

8. Appendix, including appropriate test forms that show all measured values.

E. Failure to Meet Test:

1. Any system material or workmanship which is found defective on the basis of performance tests shall be reported directly to the Architect.

2. All failed tests shall be sent immediately by email to Engineer with proposed corrective action and proposed re-test date and time.

3. Contractor shall replace the defective material or equipment as necessary, and have test repeated until test proves satisfactory without additional cost to the Owner.

4. The Contractor or testing agency shall have a calibration program which maintains all applicable test instrumentation within rated accuracy. The accuracy shall be traceable to the National Institute of Standards and Technology (NIST) in an unbroken chain. Instruments shall be calibrated in accordance with the following frequency schedule:

a. Field Instruments: 6 months
b. Laboratory Instruments: 12 months
c. Leased specialty equipment: 12 months. (Where accuracy is guaranteed by lessor).

Dated calibration labels shall be visible on all test equipment.

1.15 RECORD DOCUMENTS:

A. Refer to the Division 1 Section on Project Closeout or Project Record Documents for requirements. The following paragraphs supplement the requirements of Division 1.

B. Mark Drawings to indicate revisions to conduit size and location both exterior and interior; actual equipment locations, dimensioned from column lines; concealed equipment, dimensioned to column lines; distribution and branch electrical circuitry; fuse and circuit breaker size and arrangements; support and hanger details; Change Orders; concealed control system devices, and any other relevant deviations from the Contract Documents.

C. Mark shop drawings to indicate approved substitutions; Change Orders; actual equipment and materials used.

D. Mark luminaire schedule on drawings to indicate manufacturer and complete catalog numbers of installed equipment.

E. Mark schedules including panelboard, switchboard, motor control center, mechanical, kitchen and similar equipment schedules on drawings to indicate installed equipment and materials used, and any deviations or revisions to electrical load data and calculations.

F. During construction, the contractor shall maintain at the job site a set of updated construction documents for the singular purpose of recording the above information. All record drawings shall be completed in erasable pencil. These changes shall be updated weekly.

G. Revisions to the Contract Documents shall be legible and shall be prepared using the following color scheme.

1. Red shall indicate new items, deviations and routing.
2. Green shall indicated items removed or deleted.
3. Blue shall be used for relevant notes and descriptions.

H. At the completion of the project, submit these documents to the Architect/Engineer. This contract will not be considered completed until these record documents have been received and reviewed by the Architect/Engineer.

1.16 OPERATION AND MAINTENANCE DATA:

A. Refer to the Division 1 Section on project closeout or operation and maintenance data for procedures and requirements for preparation and submittal of maintenance manuals.

B. In addition to the information required by Division 1 for Maintenance Data, include the following information:

1. Description of function, normal operating characteristics and limitations, fuse curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shut-down, and emergency instructions; and summer and winter operating instructions.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.
5. Complete list of parts and wiring diagrams.
6. Names, addresses and telephone numbers of the Contractor, Sub-contractors and local company responsible for maintenance of each system or piece of equipment.
7. All information shall be permanently bound in a 3-ring binder. The job name and address and contractor's name and address shall be placed on the cover and spine of each binder in a permanent manner. Dymo-tape is not acceptable.
8. Copies of all test reports shall be included in the manuals.
9. Provide manuals with dividers for major sections and special equipment. Mark neatly in ink the individual equipment when more than one model or make is listed on a page. Provide detailed table of contents.
10. Final Schedule of Values with all Electrical (and Information Technology) change order costs included and identified.

C. This contract will not be considered completed nor will final payment be made until all specified material, including test reports, and final Schedule of Values with all Electrical and Information Technology change order costs included and identified is provided and the manual is reviewed by the Architect/Engineer.

1.17 WARRANTIES:

A. Refer to the Division 1 Section on Warranties and Bonds for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements. In no case shall the warranty for the total electrical system be less than one year from date of acceptance by the Owner.

B. Compile and assemble the warranties specified in Division 26, into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference.

C. Provide complete warranty information for each item. Information to include product or equipment description, date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

1.18 CONSTRUCTION REQUIREMENTS:

A. The contractor shall maintain and have available at the jobsite current information on the following at all times:

1. Up to date record drawings.
2. Submittals
3. Site observation reports with current status of all action items.
4. Test results; including recorded values, procedures, and other findings.
5. Outage information.

END SECTION 260500

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SECTION 260519 – LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.1 SUMMARY:

A. This section includes wires, cables, and connectors for power, lighting, signal, control, and related systems rated 600 volts and less.

1.2 QUALITY ASSURANCE:

A. Manufacturers: Firms regularly engaged in manufacture of electrical wire and cable products of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firm with at least 3 years of successful installation experience with projects utilizing electrical wiring and cabling work similar to that required for this project.

C. Conform to applicable code regulations regarding toxicity of combustion products of insulating materials.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's data on electrical wires, cables and connectors.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Deliver wire and cable properly packaged in factory- fabricated type containers, or wound on NEMA-specified type wire and cable reels.

B. Store wire and cable in clean dry space in original containers. Protect products from weather, damaging fumes, construction debris and traffic.

C. Handle wire and cable carefully to avoid abrasing, puncturing and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance integrity of wires/cables is maintained.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Manufacturers: Subject to compliance with requirements, provide products by the following (for each type of wire, cable, and connector):

1. Wire and Cable:
   a. American Insulated Wire
   b. Alcan
   c. Belden Div; Cooper Industries.
   d. Cerro
   e. Encore
   f. General Cable Corporation.

g. Hitemp Wires, Inc.
h. Southwire Company
i. Okonite
j. Superior Essex:
   1) Triangle
   2) Excel
   3) Royal

2. Connectors:
   a. O-Z/Gedney Co.
   b. AMP, Inc.
   c. Burndy Corporation.
   d. Ideal Industries, Inc.
   e. 3M Company
   f. Thomas and Betts Corp.

2.2 WIRES AND CABLES:

A. General: Provide wire and cable suitable for the temperature, conditions, and location where installed.

B. Conductors: Provide solid conductors for power, control, and lighting circuits 10 AWG and smaller. Provide stranded conductors for 8 AWG and larger.

C. Conductor Material: Provide copper for all wires and cables.

1. Metal Clad Cable - Type MC: Sizes 14 AWG through 10 AWG, copper conductors with 600 volt thermoplastic insulation rated 90 degrees C, steel OR aluminum interlocked metal type covering. Fitting shall be steel with double grip saddle and locking nut.

2. Portable Cord:
   a. Type SO: Sizes 14 AWG through 2 AWG, copper conductors with 600 volt thermoset insulation 0.1 resistant insulation.
   b. Type G-GC: Sizes 1 AWG through 500 KCMIL, copper conductors with 600/2000 volt, 90 degreesC, ethylene-propylene insulation.

3. Cables: Provide the following types of cables in NEC approved locations and applications where permitted by the contract documents. Cables shall be U.L. listed and approved by the local building authority. All cables shall contain a green insulated equipment ground conductor of the same size as the neutral conductor.

2.3 CONNECTORS:

A. Description: Provide UL-type factory-fabricated, solderless metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Use connectors with temperatures equal to or greater than those of the wires upon which used.

B. Provide 2-hole compression lugs for all power feeder, neutral, and grounding connections. Including phase, neutral and grounding conductors.

C. Provide connectors that are designed to accept stranded conductors where stranded conductors are used.

PART 3 EXECUTION

3.1 WIRE AND CABLE INSTALLATION SCHEDULE:

A. Building Wire: Install all building wire in raceway regardless of location.

B. Metal Clad Cable:

1. May not be used for branch circuit home runs, feeders, motor feeder circuits or in the following locations:
   a. Hazardous locations

C. Portable Cord: Use for flexible pendant leads to luminaires, outlets, and equipment where indicated and in compliance with codes.

3.2 INSTALLATION OF WIRES AND CABLES:

A. General: Install electrical cables, wires and connectors in compliance with applicable requirements of NEC, NEMA, UL, and NECA's "Standard of Installation", and in accordance with recognized industry practices.

B. Coordinate wire/cable installation work, including electrical raceway and equipment connection work, with other work.

C. Pull conductors simultaneously where more than one is being installed in same raceway. Use pulling compound or lubricant, where necessary; compound used must not deteriorate conductor or insulation.

D. Use pulling means including, fish tape, cable, rope and basket weave wire/cable grips which will not damage cables or raceway. Do not use rope hitches for pulling attachment to wire or cable.

E. Keep conductor splices to minimum. Splice only in accessible junction boxes. No splices are allowed in feeder, control or fire alarm wiring. Connect unspliced wire to numbered terminal strips at each end.

F. Install splices and taps which possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.

G. Use splice and tap connectors which are compatible with conductor material.

H. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Std 486A for copper and 486B for aluminum.

I. Support cables above accessible ceilings, do not rest on ceiling tiles. Use spring clips and hanger rods independent from the ceiling suspension system to support cables from structure.

J. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than No. 10 AWG cabled to individual circuits. Make terminations so there is no bare conductor at the terminal.

K. Use solderless pressure connectors with insulating covers for copper wire splices and taps, 8 AWG and larger. For 10 AWG and smaller, use insulated screw on type spring wire connectors with plastic caps, push on type are not acceptable.

L. Use copper compression connectors for copper wire splices and taps, 1/0 AWG and larger. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of the conductor.

M. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.

N. Thoroughly tape the ends of spare conductors in boxes and cabinets.

O. Install exposed cable, parallel and perpendicular to surfaces, or exposed structural members, and follow surface contours, where possible.

P. Make all ground, neutral and line connections to receptacle and wiring device terminals as recommended by manufacturer. Provide ground jumper from outlet box to individual ground terminal of devices.

Q. Branch circuits whose length from panel to first outlet exceeds 100 feet for 120 volt circuits or 175 feet for 277 volt circuit shall be #10 or larger, as required to comply with the National Electrical Code.

R. Parallel conductors shall be cut to the same length.

S. All splices in control panels, terminal junction boxes, low voltage control circuits, fire alarm, etc., conductors shall be on numbered terminal strip.

T. Where conduit is not required, plenum rated cable shall be provided in ceiling, floor or other air plenum spaces.

U. Provide wire training, lacing, labeling, and terminal blocks as required in panelboards and all control cabinets including, but not limited to, lighting, transfer switch, fire alarm, and security cabinets. All wiring shall be installed neat and be labeled to match wiring diagrams, control devices, etc.

1. Make temporary connections to panelboard devices with sufficient slack conductor to facilitate reconnections required for balancing loads between phases.

V. Color coding of switchlegs, travellers, etc. shall be different and distinct from phase and neutral conductors. Where systems utilize two (2) different voltages, the color coding of switchlegs, travelers, etc. shall be different and distinct for each voltage system.

3.3 FIELD QUALITY CONTROL:

A. Test installed wires and cables with 1000 VDC megohm meter to determine insulation resistance levels to ensure requirements are fulfilled. Test shall be made on all feeders regardless of size and on all branch circuits with No. 4 AWG and larger conductors. The megger values obtained shall be compared to the minimum values listed in NETA. All phase conductors and cables shall be meggered after installation, and prior to termination. Submit test report.

B. Prior to energization, test wires and cables for electrical continuity and for short-circuits.

C. Subsequent to wire and cable hook-ups, energize circuitry and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

3.4 COLOR CODING SCHEDULE:

A. Color code secondary service, feeder, and branch circuit conductors as follows:

120/208 Volts	Phase
Black	A
Red	B
Blue	C
White	Neutral
Green	Ground

B. Conductors shall be solid color for entire length.

C. If solid color conductor insulation is not available and specific acceptance is given by the engineer for use of black conductor insulation, provide the following:

1. Conductors 6 AWG and smaller shall be solid color for the entire length.

2. Conductors 4 AWG and larger shall have either solid color insulation as specified above for the entire length or be black with color coding at each termination and in each box or enclosure. For a distance of 6 inches use half-lapped ¾ inch plastic tape in the above specified color. Do not cover cable identification markings. Adjust tape locations to prevent covering of markings.

END OF SECTION 260519

SECTION 260526 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SUMMARY:

A. This Section includes solid grounding of electrical systems and equipment. It includes basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other sections of these Specifications.

1.2 SUBMITTALS:

A. Product data for ground rods, connectors and connection materials, and grounding fittings.

B. Wiring Diagrams: Submit wiring diagrams for electrical grounding and bonding work which indicates layout of ground rings, location of system grounding electrode connection, routing of grounding electrode conductors, also include diagrams for circuits and equipment grounding connections.

1.3 QUALITY ASSURANCE:

A. Listing and Labeling: Provide products specified in this Section that are listed and labeled. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.

B. Manufacturer's Qualifications: Firms regularly engaged in manufacture of grounding and bonding products, of types, and ratings required, and ancillary grounding materials, including stranded cable, copper braid and bus, grounding electrodes and plate electrodes, and bonding jumpers whose products have been in satisfactory use in similar service for not less than 5 years.

C. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with electrical grounding work similar to that required for project.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

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

1. Burndy Corporation
2. Cadweld Div.; Erico Products Inc.
3. Ideal Industries
4. OZ Gedney Div.
5. Thermoweld
6. Thomas and Betts Corp.

2.2 GROUNDING AND BONDING PRODUCTS:

A. Products: Of types indicated and of sizes and ratings to comply with NEC. Where types, sizes, ratings, and quantities indicated are in excess of NEC requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.

B. Conductor Materials: Copper.

2.3 WIRE AND CABLE CONDUCTORS:

A. General: Comply with Division 26 Section on Wires and Cables. Conform to NEC, except as otherwise indicated, for conductor properties, including stranding.

B. Equipment Grounding Conductor: Green insulated.

C. Grounding Electrode Conductor: Stranded cable.

D. Bare Copper Conductors: Conform to the following:

1. Solid Conductors: ASTM B-3.
2. Assembly of Stranded Conductors: ASTM B-8.
3. Tinned Conductors: ASTM B-33.

2.4 MISCELLANEOUS CONDUCTORS:

A. Ground Bus: Bare annealed copper bars of rectangular cross section.

B. Braided Bonding Jumpers: Copper tape, braided No. 30 gage bare copper wire, terminated with copper ferrules.

C. Bonding Strap Conductor/Connectors: Soft copper, 0.05 inch thick and 2 inches wide, except as indicated.

2.5 CONNECTOR PRODUCTS:

A. General: Listed and labeled as grounding connectors for the materials used.

B. Pressure Connectors: High-conductivity-plated units.

C. Bolted Clamps: Heavy-duty units listed for the application.

D. Exothermic Welded Connections: Provided in kit form and selected for the specific types, sizes, and combinations of conductors and other items to be connected.

2.6 GROUNDING ELECTRODES:

A. Ground Rods: Copper-clad steel with high-strength steel core and electrolytic-grade copper outer sheath, molten welded to core.

1. Size: ¾” by 10 feet.

PART 3 EXECUTION

3.1 APPLICATION:

A. Equipment Grounding Conductor Application: Comply with NEC for sizes and quantities of equipment grounding conductors, except where larger sizes or more conductors are indicated.

1. Install separate insulated equipment grounding conductors with circuit conductors for the following in addition to those locations where required by Code:

a. Feeders and branch circuits.

b. Provide individual grounding and neutral conductors for each isolated ground receptacle. When individual or groups of isolated ground receptacles are on dedicated circuits, individual ground and neutral conductors for each circuit is acceptable.

2. Busway Circuits: Install separate insulated equipment ground conductor from the ground bus in the switchgear, switchboard, or distribution panel to the equipment ground bar terminal on the busway.

3. Nonmetallic Raceways: Install an insulated equipment ground conductor in nonmetallic raceways unless they are designated for telephone or data cables.

4. Air Duct Equipment Circuits: Install an insulated equipment grounding conductor to duct-mounted electrical devices operating at 120-V and above including air cleaners and heaters. Bond the conductor to each such unit.

5. Water Heater, Heat Tracing, and Anti-Frost Heater Circuits: Install separate insulated equipment ground conductor to each electric water heater, heat tracing, and surface anti-frost heating cable. Bond this conductor to heater units, piping, and connected equipment and components.

B. Underground Conductors: Bare, tinned, stranded copper except as otherwise indicated.

C. Signal and Communications: For telephone, alarm, and communication systems, provide a #6 AWG minimum green insulated copper conductor in raceway from the grounding electrode system to each terminal cabinet or central equipment location.

D. All systems shall be grounded in accordance with the NEC.

3.2 INSTALLATION:

A. General: Ground electrical systems and equipment in accordance with NEC requirements except where the Drawings or Specifications exceed NEC requirements. Connect together system neutral, service equipment enclosures, exposed noncurrent carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground connectors, and plumbing systems.

B. Electrical Room Ground Bus: Size, location, and arrangement as indicated. Space 1 inch from wall and support from wall 6 inches above finished floor, except as otherwise indicated.

C. Ground Rods: Locate a minimum of two-rod lengths from each other and at least the same distance from any other grounding electrode. Interconnect ground rods with bare conductors buried at least 24 inches below grade. Connect bare-cable ground conductors to ground rods by means of exothermic welds except as otherwise indicated. Make these connections without damaging the copper coating or exposing the steel. Drive rods until tops are 6 inches below finished floor or final grade except as otherwise indicated.

D. Metallic Water Service Pipe:

1. Provide insulated copper ground conductors, sized as indicated, in conduit from the building main service equipment, or the ground bus, to main metallic water service entrances to the building. Connect ground conductors to the main metallic water service pipes by means of ground clamps. Where a dielectric main water fitting is installed, connect the ground conductor to the street side of the fitting. Do not install a grounding jumper around dielectric fittings. Provide grounded bushing at conduit ends and bond the ground conductor conduit to the ground bars at each end.

2. Where more than one metallic water service exists, provide insulated copper ground conductors sized to match the water service bonding jumper, in conduit, to the main service equipment main ground bus or to the other water service entrance. Provide grounded bushing at conduit ends and bond to ground bars at grounding conductor termination.

E. Braided-Type Bonding Jumpers: Install to connect ground clamps on water meter piping to bypass water meters electrically. Use elsewhere for flexible bonding and grounding connections.

F. Route grounding conductors along the shortest and straightest paths possible without obstructing access or placing conductors where they may be subjected to strain, impact, or damage, except as indicated.

G. UFER Ground: Fabricate grounding electrode conductor by installing lengthwise in form for foundation or footings. Install so conductor is within 2 inches of the bottom of the concrete. Extend conductor below grade and connect to building grounding grid, grounding electrode, or ground bar as required and as shown on plan drawings and details.

H. Labeling: Provide a phenolic tag for all grounding electrode conductors as described in section on Electrical Identification.

I. Where grounding conductors, grounding electrode conductors, or bonding conductors are non-exposed, identify each with a 6-inch band of green tape at each end and at 10 foot intervals. When run in conduits, provide color banding on conduit per section on Electrical Identification.

3.3 CONNECTIONS:

A. General: Make connections in such a manner as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to assure high conductivity and make contact points closer in order of galvanic series.

2. Make connections with clean bare metal at points of contact.

3. Coat and seal connections involving dissimilar metals with inert material such as red lead paint to prevent future penetration of moisture to contact surfaces.

B. Exothermic Welded Connections: Use for connections to structural steel and for underground connections except those at test wells. Install at connections to ground rods and plate electrodes. Comply with manufacturer's written recommendations. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Terminate insulated equipment grounding conductors for feeders and branch circuits with pressure-type grounding lugs. Where metallic raceways terminate at metallic housings without mechanical and electrical connection to the housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to the ground bus in the housing. Bond electrically noncontinuous conduits at both entrances and exits with grounding bushings and bare grounding conductors. Terminate each conductor on an individual ground lug terminal.

D. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with torque tightening values specified in UL 486A.

E. Compression-Type Connections: Use hydraulic compression tools to provide the correct circumferential pressure for compression connectors. Use tools and dies recommended by the manufacturer of the connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on the ground conductor.

F. Moisture Protection: Where insulated ground conductors are connected to ground rods or ground buses, insulate the entire area of the connection and seal against moisture penetration of the insulation and cable.

3.4 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING:

A. Pad Mounted Gear: Install a ¾ inch by 10 feet. Driven ground rod inside the cable access blockout of the pad and set the rod depth such that 4 inches will extend above the finished pad. Where necessary, install ground rod before the equipment is placed. Protect ground rods passing through concrete with a double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below the concrete.

B. Grounding System: Ground non-current-carrying metallic items associated with pad-mounted equipment by connecting them to grounding electrodes arranged as indicated.

3.5 FIELD QUALITY CONTROL:

A. Upon completion of installation of electrical grounding and bonding systems, test ground resistance with ground resistance tester. Where tests show resistance-to-ground is over 5 ohms, take appropriate action to reduce resistance to 5 ohms, or less, by driving additional ground rods; then retest to demonstrate compliance.

B. Ground Resistance Test:

1. Grounding electrode resistance testing shall be accomplished with a ground resistance direct-reading single test meter utilizing the fall-of-potential method and two reference electrodes. Perform test prior to interconnection to other grounding systems. Orient the ground electrode to be tested and the two reference electrodes in a straight line spaced fifty (50) feet apart. Drive the two reference electrodes five (5) feet deep.

C. Correct Deficiencies, Retest and Report:

1. Correct unsatisfactory conditions and retest to demonstrate compliance; replace conductors, units and rods as required to bring system into compliance.

2. Prepare a written report and show temperature, humidity and condition of soil at time of tests. Report shall be certified by testing agency that identifies components checked and describes results. Include notation of deficiencies detected, remedial action taken, and observations and test results after remedial action.

3.6 CLEANING AND ADJUSTING:

A. Restore surface features at areas disturbed by excavation and reestablish original grades except as otherwise indicated. Where sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other Work to their original condition. Include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching. Restore vegetation and disturbed paving to original condition.

END OF SECTION 260526

SECTION 260529 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SUMMARY:

A. This Section includes secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.

1.2 SUBMITTALS:

A. Product data for each type of product specified.

1. Hanger and support schedule showing manufacturer's figure number, size, spacing, features, and application for each required type of hanger, support, sleeve, seal, and fastener to be used.

B. Shop drawings indicating details of fabricated products and materials.

C. Engineered Design consisting of details and engineering analysis for supports for the following items:

1. Trapeze hangers for multiple conduit runs.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

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

1. Slotted Metal Angle and U-Channel Systems:

a. Allied Tube & Conduit
b. B-Line Systems, Inc.
c. Unistrut Diversified Products

2. Conduit Sealing Bushings:

a. O-Z/Gedney
b. Cooper Industries, Inc.
c. Killark Electric Mfg. Co.
d. Madison Equipment Co.
e. Raco, Inc.
f. Spring City Electrical Mgf. Co.
g. Thomas & Betts Corp.

2.2 COATINGS:

A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.

2.3 MANUFACTURED SUPPORTING DEVICES:

A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.

B. Fasteners: Types, materials, and construction features as follows:

1. Expansion Anchors: Carbon steel wedge or sleeve type.
2. Toggle Bolts: All steel springhead type.
3. Powder-Driven Threaded Studs: Heat-treated steel, designed specifically for the intended service.

C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.

E. U-Channel Systems: 12-gage steel channels, with 9/16 inch-diameter holes, at a minimum of 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture.

F. Supports: Provide supporting devices of types, sizes and materials indicated; and having the following construction features:

1. One-Hole Conduit Straps: For supporting ¾ inch and smaller rigid metal conduit; galvanized steel.

2. Two-Hole Conduit Straps: For supporting 1 inch and larger rigid metal conduit, galvanized steel; ¾ inch strap width; and 2-1/8 inch between center of screw holes.

2.4 FABRICATED SUPPORTING DEVICES:

A. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.

B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

C. Pipe Sleeves: Provide pipe sleeves of one of the following:

1. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.
2. EMT, IMC, or Rigid Conduit.

PART 3 EXECUTION

3.1 INSTALLATION:

A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.

B. Coordinate with the building structural system and with other electrical installation.

C. Junction Box Supports: Comply with the NEC and the following requirement:

1. Use ¼" all-thread rod from structure to support junction boxes.

D. Raceway Supports: Comply with the NEC and the following requirements:

1. Conform to manufacturer's recommendations for selection and installation of supports.

2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs, provide additional strength until there is a minimum of 200 lbs safety allowance in the strength of each support.

3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.

4. Use #9 ceiling wire to support individual conduits up to 3/4inch with spring steel fasteners. Use of ceiling support wires is unacceptable.

5. Support parallel runs of horizontal raceways together on trapeze-type hangers. Use 3/8 inch diameter or larger threaded steel rods for support.

6. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2 inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use ¼ inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing. For hanger rods supporting 1-1/2 inch or larger conduits provide 3/8 inch minimum threaded steel rods with pipe hangers.

7. Space supports for raceways in accordance with NEC. When there are 4 or more 2 inch conduits in a trapeze, supports shall be spaced 5 feet O.C.

8. In all runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.

9. Threaded rod supports to have bottoms cut off at a maximum length equal to rod diameter below bottom nut.

E. Conductor Supports: Comply with the NEC and the following requirements:

1. Support individual conductors or cables by separate clamps with rubber or plastic grommet, fasten using a non-metallic bolt and nut, and secure clamps to unistrut supports anchored to structure (multiple clamps may be secured to a single unistrut

support). Individual conductors or cables may be served utilizing a vinyl or fiberglass clamp which shall be anchored to the structure.

2. Space supports as follows:

   a. Horizontal conductors not more than 3 feet o.c.
   b. Vertical conductors not more than 5 feet o.c.

3. Install simultaneously with installation of conductors.

F. Miscellaneous Supports: Support miscellaneous electrical components separately and as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

G. In overhead spaces, support metal boxes directly from the building structure via 1/4" minimum all-thread or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box. Supporting metal boxes utilizing ceiling type wire is not acceptable.

H. Sleeves: Install in concrete slabs and walls and all other fire-rated floors and walls for cable installations as required. Where sleeves through floors are installed, extend above finish floor. For sleeves through fire rated-wall or floor construction, apply UL-listed firestopping sealant in gaps between sleeves and cables in accordance with "Fire Resistant Joint Sealers" requirement of Division 7 Section "Joint Sealers." See Architectural plans for location and extent of fire rated assemblies.

I. Conduit Seals: Install seals for conduit penetrations of exterior walls below grade. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.

J. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with the following:

1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws, where authorized by the Owner and structural engineer. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.

2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.

3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock-resistant fasteners for attachments to concrete slabs.

K. Communication and Telephone Cable Supports: Use No. 9 ceiling wire to support individual or small bundles of cables run above accessible ceilings.

3.2 PERSONNEL PROTECTION:

A. Where U-channel systems, angles, brackets or other standard structural metal shapes are readily accessible and exposed to personnel, provide plastic or rubber end caps.
B. Where threaded rod supports are readily accessible and exposed to personnel, provide plastic or rubber end caps.

END OF SECTION 260529

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SECTION 260533 RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SUMMARY:

A. Extent of raceway work is indicated by drawings and schedules. Provide complete conduit systems for all conductors unless otherwise specified.

B. Types of raceways specified in this section include the following:

1. Electrical metallic tubing (EMT).
2. Flexible metal conduit.
3. Intermediate metal conduit (IMC).
4. Liquid-tight flexible metal conduit.
5. Non-metallic Conduit and Ducts.
6. Rigid metal conduit (RGC).
7. Surface metal raceways.
8. Wireways.
9. Rigid Aluminum Conduit.

1.2 QUALITY ASSURANCE:

A. Manufacturers: Firms regularly engaged in manufacture of raceway systems of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with electrical raceway work similar to that required for this project.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including specifications and installation instructions, for each type of raceway system required. Include data substantiating that materials comply with requirements.

B. Shop Drawings: Submit dimensioned drawings of surface metal raceway systems showing layout of raceways and fittings, spatial relationships to associated equipment, and adjoining raceways, if any. Show connections to electrical power panels and feeders.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Rigid Metal Conduit:

a. Allied
b. Wheatland
c. Triangle

d. Western Tube & Conduit

2. Intermediate Metal Conduit (IMC):

a. Allied
b. Triangle
c. Western Tube & Conduit

3. PVC Coated:

a. Rob Roy
b. Perma Cote
c. OCAL

4. EMT Conduit:

a. Allied
b. Republic
c. Triangle
d. LTV
e. Western Tube & Conduit

5. Non-Metallic Conduit:

a. Carlon
b. MPF
c. Can-Tex
d. PW

6. Steel Fittings:

a. O/Z Gedney
b. Raco
c. Appleton
d. EPT
e. Midwest
f. Picoma
g. Steel City

7. Conduit Bodies:

a. O/Z Gedney
b. Killark
c. Regal
d. Appleton
e. Crouse Hinds

8. Wireway:

a. Square D. Co.
b. Circle AW Products

c. Erickson Electric Equipment Co.
d. G.S. Metals Corp.
e. Hoffman Engineering Co.
f. Wadsworth Electric Mfg. Co., Inc.

2.2 METAL CONDUIT AND TUBING:

A. Rigid Galvanized Steel Conduit (RGC):

1. Conduit: Rigid steel, zinc-coated inside and outside, threaded ends.
2. Fittings: Threaded galvanized steel, bushings shall have nylon insulated throat.

B. Intermediate Metal Conduit (IMC):

1. Conduit: Rigid intermediate grade galvanized inside and outside, threaded ends.
2. Fittings: Threaded galvanized steel, bushings shall have nylon insulated throat.

C. PVC Externally Coated Rigid Steel Conduit:

1. Conduit: Rigid steel zinc-coated with external coating of PVC.
2. Fittings: Threaded galvanized steel with external PVC coating, bushings shall have nylon insulated throat.

D. Electrical Metallic Tubing (EMT):

1. Conduit: Galvanized steel tubing.
2. Fittings: Steel compression fittings for all applications. Bushings shall be threaded and have nylon insulated throat or nylon bushing.

E. Rigid Aluminum Conduit:

1. Not allowed unless otherwise noted.

F. Flexible Metal Conduit:

1. Conduit: Continuous spiral wound, interlocked, zinc-coated steel, approved for grounding.

2. Fittings: Cadmium plated, malleable iron. Straight connector shall be one-piece body, female end with clamp and deep slotted machine screw for securing conduit, and threaded male end provided with a locknut. Angle connectors shall be two piece body with removable upper section, female end with clamp and deep slotted machine screw for securing conduit, and threaded male end provided with a locknut. All fittings shall be terminated with threaded bushings having nylon insulated throats.

G. Liquid-Tight Flexible Metal Conduit:

1. Conduit: Continuous spiral wound, interlocked zinc-coated steel with polyvinyl chloride (PVC) jacket, approved for grounding.

2. Fittings: Cadmium plated malleable iron. Straight and angle connectors shall be the same as used with flexible metal conduit but shall be provided with a compression type steel ferrule and neoprene gasket sealing rings.

2.3 NON-METALLIC CONDUIT AND DUCTS:

A. Rigid Non-Metallic Conduit (RNC):

1. Conduit: Schedule 40 polyvinyl chloride (PVC), 90°C for direct burial or concrete encasement.
2. Fittings: Mate and match conduit type and material. Cement as recommended by manufacturer.

2.4 CONDUIT BODIES:

A. General: Types, shapes and sizes, as required to suit individual applications and NEC requirements. Provide matching gasketed covers secured with corrosion-resistant screws.

B. Metallic Conduit and Tubing: Use malleable iron conduit bodies. Use bodies with threaded hubs for threaded raceways and in hazardous locations.

C. Nonmetallic Conduit: Use nonmetallic conduit bodies.

2.5 WIREWAYS:

A. General: Provide electrical wireways of types, grades, sizes, and number of channels for each type of service as indicated. Provide complete assembly of raceway including, but not limited to, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other components and accessories as required for complete system.

B. Lay-In Wireways: Construct lay-in wireways with hinged covers in accordance with UL 870 with components UL listed. Construct units to be capable of sealing cover in closed position with sealing wire. Provide wireways with knockouts.

1. Connectors: Provide wireway connectors suitable for "lay-in" conductors, with connector covers permanently attached so that removal is not necessary to utilize the lay-in feature.

2. Finish: Protect sheet metal parts with rust inhibiting coating and baked enamel finish. Plate finish hardware to prevent corrosion. Protect screws installed toward inside of wireway with spring nuts to prevent wire insulation damage.

C. Rain-tight Troughs: Construct in accordance with UL 870, with components UL listed.

1. Construction: 16-gauge galvanized sheet metal parts for 4" x 4" to 6" x 6" sections, and 14 gauge parts for 8" x 8" and larger sections. Provide knockouts only in bottom of troughs, with suitable adapters to facilitate attaching to other NEMA 3R enclosures. Do not use gasketing that can rip or tear during installation, or would compromise rain-tight capability of the trough. Do not use cover screws that will protrude into the trough area and damage wire insulation.

2. Finish: Provide 14-gauge and 16-gauge galvanized sheet metal parts with corrosion-resistant phosphate primer and baked enamel finish. Plate hardware to prevent corrosion.

2.6 CONDUIT SIZES:

A. Conduit sizes shall be as shown on the drawings. If the conduit size is not given on the drawings, the conduit shall be sized in accordance with NEC based on the number of conductors enclosed plus a parity sized equipment ground conductor and be subject to the following minimum sizes:

1. Rigid, Intermediate, and EMT Conduit: 3/4 inch for all runs except lighting switch legs, 277 volt lighting branch circuits, temperature control and fire alarm which may be 1/2inch.
2. Flexible and Liquid-Tight Flexible Conduit: 1/2inch for all runs.
3. MC Cable: 3/8 inch to undercounter luminaires, 1/2inch for all other runs.
4. Underground or Concrete Encased Nonmetallic Conduit: 3/4inch for all runs.
5. Conduits used for home runs shall contain only the conductors for the circuits indicated on the drawings. Combining multiple home runs into a single conduit will not be permitted.

2.7 RACEWAY SEALING COMPOUND:

A. Nonhardening, safe for human skin contact, not deleterious to cable insulation, workable at temperatures as low as 35 deg F (1 deg C), withstands temperature of 300 deg F (149 deg C) without slump, and adheres to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials and the common metals.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which raceways are to be installed, and substrate which will support raceways. Notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 CONDUIT SCHEDULE:

A. Buried Raceways: PVC Coated rigid steel galvanized conduit or Schedule 40 OR 80, rigid PVC plastic conduit.

B. Raceways embedded in concrete slabs or walls in contact with earth: Schedule 40, PVC plastic conduit. PVC coated rigid steel galvanized conduit, OR PVC coated intermediate metal conduit.

C. Raceways embedded in concrete slabs above grade level: Rigid steel galvanized conduit or Schedule 40 OR 80 rigid PVC plastic conduit in slab.

D. Raceways Through Foundation Walls Below Grade: One 10 foot section of PVC coated rigid steel galvanized, extending from 1 foot inside the foundation wall.

E. Hazardous areas: Rigid steel galvanized conduit.

F. Raceways in locations subject to mechanical injury: Rigid steel galvanized conduit OR intermediate metal conduit. Locations subject to mechanical injury include, but are not limited to, the following:

1. Exposed conduits outdoors up to 8’ A.F.G.
2. Exposed conduits in dock areas and high/medium bay locations up to 25 feet above finished floor.
3. Exposed conduits in parking garages.
4. Exposed conduits in a Fire Pump Room.
5. Exposed service entrance feeders.

G. Motor and equipment connections: PVC jacketed liquid-tight flexible metallic conduit with liquid tight connectors.

H. Raceways in all other areas shall be electrical metallic tubing unless otherwise noted.

I. Use flexible metal conduit inside movable partition wireways, from junction boxes to devices and between devices in casework, from outlet boxes to recessed luminaires, and for "fishing" of existing walls.

3.3 INSTALLATION OF CONDUITS:

A. General: Install electrical raceways in accordance with manufacturer's written installation instruction, applicable requirements of NEC, and as follows:

1. Conceal all conduit unless indicated otherwise, within finished walls, ceilings, and floors. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot water pipes. Install raceways level and square and at proper elevations.

2. Elevation of Raceway:

a. Where horizontal raceway is installed near water and steam piping, route raceway above piping and as close to structure as possible and practical.

b. Route raceway as close to structure as possible.

3. Complete installation of electrical raceways before starting installation of conductors within raceways.

4. Provide supports for raceways as specified elsewhere in Division 16.

5. Prevent foreign matter from entering raceways by using temporary closure protection.

6. Protect stub-ups from damage where conduits rise from floor slabs. Arrange so curved portion of bend is not visible above the finished slab.

7. Make bends and offsets so the inside diameter is not effectively reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.

8. Use raceway fittings that are types compatible with the associated raceway and suitable for the use and location. Install expansion fittings across all structural construction joints and expansion/deflection couplings across all structural expansion joints.

9. Run raceways parallel and perpendicular to building elements and other equipment with a minimum of bends in the shortest practical distance considering the type of building construction and obstructions except as otherwise indicated.

10. Raceways embedded in slabs: (Allowed only by written authorization of Structural Engineer/Architect): Install with a minimum of bends, in the shortest practical distance, in middle third of the slab thickness where practical, and leave at least 1 inch concrete cover. Tie raceways to reinforcing rods or otherwise secure them to prevent sagging or shifting during concrete placement. Space raceways laterally to prevent voids in the concrete. Run conduit larger than 1inch trade size, parallel with or at right angles to the main reinforcement; where at right angles to the reinforcement, the conduit shall be close to one of the supports of the slab. Where nonmetallic conduit is used, raceways must be converted to PVC coated rigid steel conduit before rising above floor.

11. Install exposed raceways parallel and perpendicular to nearby surfaces or structural members and follow the surface contours as much as practical.

12. Install vertical feeder conduits in exterior walls, core walls, or chase spaces. Do not install in interior wall partition areas.

13. Run exposed and parallel raceways together. Make bends in parallel runs from the same center line so that the bends are parallel. Factory elbows may be used only where they can be installed parallel. In other cases provide field bends for parallel raceways.

14. Make raceway joints tight. Where joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system. Make raceway terminations tight. Where terminations are subject to vibration, use bonding bushings or wedges to assure electrical continuity. Where subject to vibration or dampness, use insulating bushings to protect conductors. Joints in non-metallic conduits shall be made with solvent cement in strict accordance with manufacturer's recommendations.

15. Tighten set screws of threadless fittings with suitable tool.

16. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished part against the box. RGC and IMC shall be secured with double locknuts and an insulated metallic bushing. EMT shall be secured with one locknut and shall have nylon insulated throats or threaded nylon bushings from 1/2" to 1". 1-1/4" and above shall be metal with nylon insulated throats. Use grounding type bushings for feeder conduits at switchboards, panelboards, pull boxes, transformers, motor control centers, VFD's, etc.

17. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align

the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.

18. Provide nylon pull string with printed footage indicators having not less than 200 pounds tensile strength. Leave not less than 12 inches of slack at each end of the pull string. Identify with tags at each end the origin and destination of each empty conduit and indicate same on all empty or spare conduits on the as-built drawings.

19. Install raceway sealing fittings in accordance with the manufacturer's written instructions. Locate fittings at suitable, approved, accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points and elsewhere as indicated:

    a. Where conduits enter or leave hazardous locations.

    b. Where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces and air-conditioned spaces.

    c. Where conduits enter through a foundation wall or stub-up through a slab on grade floor.

    d. Where required by the NEC.

20. Install raceway/duct sealing compound inside of all underground stub into a building through a foundation wall or through a slab on grade floor.

21. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment with an adjustable top or coupling threaded inside for plugs and set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; flexible metal conduit may be used 6 inches above the floor. Where equipment connections are not made under this contract, install screwdriver-operated threaded plugs flush with floor.

22. Flexible Connections: Use short length (maximum of 6 feet) of flexible conduit for recessed and semi-recessed luminaires, for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquid-tight flexible conduit in wet locations. Install separate ground conductor across flexible connections.

23. PVC externally coated rigid steel conduit: Patch all nicks and scrapes in PVC coating after installing conduit.

24. Where conduits are to be installed through structural framing members, the Contractor shall provide sleeves. The Architect/Engineer's written approval must be obtained prior to cutting, notching or drilling of structural framing members.

25. Ream the ends of all cut and/or threaded conduit. Ends shall be cut square.

26. Use of running threads for rigid or intermediate metallic conduit are not permitted. When threaded couplings cannot be used, provide 3 piece union or solid coupling.

27. Route conduit through roof openings for piping and ductwork where possible; otherwise, rout through jack with pitch pocket.

28. Conduit stub-ups from below grade or thru the slab shall be PVC coated rigid steel galvanized conduit and shall extend 6 inches above grade.

29. Wherever conduits enter a structure through a foundation or basement wall below grade, grout around the conduit with water-proof grout or install entrance seals. Seals shall be OZ Type WS or approved equivalent for new construction and OZ type CSM Series for existing structures.

30. Conduits shall not cross pipe shafts or ventilation duct openings. Where conduits must penetrate air-tight spaces or plenums, seal around the conduit with a mastic acceptable to the Architect/Engineer.

31. Install an insulated ground conductor in all conduits.

32. Where individual conduits penetrate existing fire-rated walls and floors, pack void around conduit with fire rated insulation and seal opening around conduit with UL listed forma silicone elastomer compound. Where conduits penetrate exterior walls, new floors, or roof, provide pipe sleeve one size larger than conduit, pack void around conduit with fire rated insulation, and seal opening around conduit with UL listed foam silicone elastomer compound.

33. Where conduit sleeves penetrate fire rated floors or walls for installation of system cables, AC or MC cables, or modular wiring cables pack void around cables or empty sleeve with fire rated insulation and fill ends with fire-resistive compound. Seal opening around sleeve with UL listed foam silicone elastomer compound.

34. Use PVC-coated rigid steel factory elbows for bends in plastic conduit runs longer than 100 feet, or in plastic conduit runs which have more than two bends regardless of length. Use long sweep bends for wiring larger than 350 mcm.

35. Wipe plastic conduit clean and dry before joining. Apply full even coat of cement to entire area that will be inserted into fitting. Let joint cure for 20 minutes minimum.

36. No PVC conduit shall be run exposed or inside stud or masonry walls unless specifically called for on the drawings. Transition from PVC to metal conduit shall be made below grade.

37. Provide separate raceway systems for each of the following:

    a. Lighting
    b. Power Distribution
    c. Communications and Data
    d. Fire Alarm

38. Provide rebar and tie downs for all conduits and conduit racks to be installed with concrete or slurry to prevent conduit “float”.

B. Install buried electrical line warnings per Division 26 section - “Electrical identification”.

C. Install labeling as required in Division 26 section - “Electrical Identification”.

3.4 ADJUSTING AND CLEANING:

A. Upon completion of installation of raceways, inspect interiors of raceways; clear all blockages and remove burrs, dirt and construction debris.

END OF SECTION 260533

SECTION 260534 CABINETS, BOXES, AND FITTINGS

PART 1 GENERAL

1.1 SUMMARY:

A. This section includes cabinets, boxes, and fittings for electrical installations and certain types of electrical fittings not covered in other sections. Types of products specified in this section include:

1. Outlet and device boxes.
2. Pull and junction boxes.
3. Floor boxes and service fittings.
4. Cabinets.
5. Hinged door enclosures.
6. Boxes and fittings for hazardous locations.

B. Conduit-body-type electrical enclosures and wiring fittings are specified in the Division 26 Section on Raceways.

1.2 DEFINITIONS:

A. Cabinets: An enclosure designed either for surface or for flush mounting and having a frame, or trim in which a door or doors may be mounted.

B. Device Box: An outlet box designed to house a receptacle device or a wiring box designed to house a switch.

C. Enclosure: A box, case, cabinet, or housing for electrical wiring or components.

D. Hinged Door Enclosure: An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box.

E. Outlet Box: A wiring enclosure where current is taken from a wiring system to supply utilization equipment.

F. Wiring Box: An enclosure designed to provide access to wiring systems or for the mounting of indicating devices or of switches for controlling electrical circuits.

1.3 SUBMITTALS:

A. Submit product data for cabinets and enclosures with classification higher than NEMA 1.

B. Shop drawings for floor boxes and boxes, enclosures and cabinets that are to be shop fabricated, (non-stock items). For shop fabricated junction and pull boxes, show accurately scaled views and spatial relationships to adjacent equipment. Show box types, dimensions, and finishes.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

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

1. Floor Boxes:

a. Wiremold
b. Butler Mfg. Co.
c. Cooper Industries, Inc.
d. Raco, Inc.
e. Thomas & Betts Corp.

2. Cabinets:

a. Hoffman Engineering Co.
b. Erickson Electrical Equipment Co.
c. Electric Panelboard, Inc.
d. Parker Electrical Mfg. Co.
e. Spring City Electrical Mfg. Co.
f. Square D Co.
g. Circle AW

3. Boxes and Fittings for Hazardous Locations:

a. OZ/Gedney.
b. Cooper Industries, Inc.
c. Killark Electric Mfg. Co.
d. Adalet-PLM.
e. Robroy Industries, Inc.
f. Spring City Electrical Mfg. Co.
g. Appleton

2.2 CABINETS, BOXES, AND FITTINGS, GENERAL:

A. Electrical Cabinets, Boxes, and Fittings: Of indicated types, sizes, and NEMA enclosure classes. Where not indicated, provide units of types, sizes, and classes appropriate for the use and location. Provide all items complete with covers and accessories required for the intended use. Provide gaskets for units in damp or wet locations.

2.3 MATERIALS AND FINISHES:

A. Sheet Steel: Flat-rolled, code-gage, galvanized steel.

B. Fasteners for General Use: Corrosion resistant screws and hardware including cadmium and zinc plated items.

C. Fasteners for Damp or Wet Locations: Stainless steel screws and hardware.

D. Cast Metal for Boxes, Enclosures, and Covers; Copper-free aluminum except as otherwise specified.

E. Exterior Finish: Gray baked enamel for items exposed in finished locations except as otherwise indicated.

F. Painted Interior Finish: Where indicated, white baked enamel. Emergency system cabinets and boxes shall be red.

G. Fittings for Boxes, Cabinets, and Enclosures: Conform to UL 514B. Malleable iron or zinc plated steel for conduit hubs, bushings and box connecters.

2.4 METAL OUTLET, DEVICE, AND SMALL WIRING BOXES:

A. General: Conform to UL 514A, "Metallic Outlet Boxes, Electrical," and UL 514B, "Fittings for Conduit and Outlet Boxes." Boxes shall be of type, shape, size, and depth to suit each location and application.

B. Steel Boxes: Conform to NEMA OS 1, "Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports." Boxes shall be sheet steel with stamped knockouts, threaded screw holes and accessories suitable for each location including mounting brackets and straps, cable clamps, exterior rings and fixture studs.

C. Cast-Aluminum Boxes: Copper free aluminum threaded raceway entries, and features and accessories suitable for each location including mounting ears, threaded screw holes for devices and closure plugs.

D. Malleable or Cast-Iron Boxes: Iron alloy, waterproof, with threaded raceway entries and features and accessories suitable for each location, including mounting ears, threaded screw holes for devices and closure plugs.

E. Malleable or Cast-Iron Floor Boxes: Fully adjustable, waterproof, with threaded raceway entrances, adjusting rings, gaskets, and brass floor plates. Where indicated, provide multi-section boxes with individual hinged section covers. Provide for power, data, and communication outlets as indicated on the drawings.

F. Steel Floor Boxes: Sheet steel, concrete tight, fully adjustable, with stamped knockouts, adjusting rings, and brass floor plates. Where indicated, provide multi-section boxes with concealed individual section covers under a common flush floor plate. Provide for power, data, and communication outlets as indicated on the drawings.

G. Service Fittings for Floor Outlet Boxes: Surface mounted horizontal, cast aluminum type 3-inches high, suitable for finished spaces and finished in satin aluminum, except as otherwise indicated. Provide duplex receptacle or 1-inch bushed opening for telephone or other communications service as indicated. Equip fitting for attaching flat to floor box cover.

H. Concealed Service Floor Box: Malleable, cast iron, or steel floor boxes as specified above designed to deliver power, data, and communications services from outlets concealed within the box and accessible through a single hinged cover. The cover shall fit into the top of the floor box and include a carpet or tile floor flange, a hinged steel reinforced floor plate with provision for mounting a piece of carpet or tile, and a small retractable cable exit. Provide for power, communications, and data outlets as indicated on the drawings.

2.5 PULL AND JUNCTION BOXES:

A. General: Comply with UL 50, "Electrical Cabinets and Boxes", for boxes over 100 cubic inches volume. Boxes shall have screwed or bolted on covers of material same as box and shall be of size and shape to suit application.

B. Steel Boxes: Sheet steel with welded seams. Where necessary to provide a rigid assembly, construct with internal structural steel bracing.

C. Hot-Dipped Galvanized Steel Boxes: Sheet steel with welded seams. Where necessary to provide a rigid assembly, construct with internal structural steel bracing. Hot-dip galvanized after fabrication. Cover shall be gasketed.

D. Stainless-Steel Boxes: Fabricate of stainless steel conforming to Type 302 of ASTM A 167, "Specification for Stainless and Heat Resisting Chromium-Nickel Steel Plate, Sheet, and Strip." Where necessary to provide a rigid assembly, construct with internal structural stainless steel bracing. Cover shall be gasketed.

E. Cast-Aluminum Boxes: Molded of copper free aluminum, with gasketed cover and integral threaded conduit entrances.

F. Malleable or Cast-Iron Boxes: Molded of iron alloy with gasketed cover and integral threaded conduit entrances.

G. Boxes Approved for Classified Locations: Cast metal boxes conforming to UL 886, "Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations," listed and labeled for use in the specific location classification, and with the specific hazardous material encountered. Conduit entrances shall be integral threaded type.

2.6 CABINETS:

A. Comply with UL 50, "Electrical Cabinets and Boxes."

B. Construction: Sheet steel, NEMA 1 class except as otherwise indicated. Cabinet shall consist of a box and a front consisting of a one piece frame and a hinged door. Arrange door to close against a rabbet placed all around the inside edge of the frame, with a uniformly close fit between door and frame. Provide concealed fasteners, not over 24 inches apart, to hold fronts to cabinet boxes and provide for adjustment. Provide flush or concealed door hinges not over 24 inches apart and not over 6 inches from top and bottom of door. For flush cabinets, make the front approximately ¾” larger than the box all around. For surface mounted cabinets make front same height and width as box.

C. Doors: Double doors for cabinets wider than 24 inches. Telephone cabinets wider than 48 inches may have sliding or removable doors.

D. Locks: Combination spring catch and key lock, with all locks for cabinets of the same system keyed alike. Locks may be omitted on signal, power, and lighting cabinets located within wire closets and mechanical-electrical rooms. Locks shall be of a type to permit doors to latch closed without locking.

2.7 STEEL ENCLOSURES WITH HINGED DOORS:

A. Comply with UL 50, "Cabinets and Enclosures" and NEMA ICS 6, "Enclosures for Industrial Controls and Systems."

B. Construction: Sheet steel, 16 gage, minimum, with continuous welded seams. NEMA class as indicated; arranged for surface mounting.

C. Doors: Hinged directly to cabinet and removable, with approximately ¾ inch flange around all edges, shaped to cover edge of box. Provide handle operated, key locking latch. Individual door width shall be no greater than 24 inches. Provide multiple doors where required.

D. Mounting Panel: Provide painted removable internal mounting panel for component installation.

E. Enclosure: NEMA 1 except as indicated. Where door gasketing is required, provide neoprene gasket attached with oil-resistant adhesive, and held in place with steel retaining strips. For all enclosures of class higher than NEMA 1, use hubbed raceway entrances.

PART 3 EXECUTION

3.1 INSTALLATION, GENERAL:

A. Locations: Install items where indicated and where required to suit code requirements and installation conditions.

B. Cap unused knockout holes where blanks have been removed and plug unused conduit hubs.

C. Support and fasten items securely in accordance with Division 26 Section on Supporting Devices.

D. Sizes shall be adequate to meet NEC volume requirements, but in no case smaller than sizes indicated.

E. Remove sharp edges where they may come in contact with wiring or personnel.

3.2 APPLICATIONS:

A. Cabinets: Flush mounted, NEMA enclosure type 1 except as otherwise indicated.

B. Hinged Door Enclosures Indoor: NEMA type 1 enclosure except as indicated.

C. Hinged Door Enclosures Outdoors: NEMA Type 4. Install drip hood, factory tailored to individual units.

D. Hinged Door Enclosures in Corrosive Locations: NEMA type 4X nonmetallic enclosure.

E. Outlet Boxes and Fittings: Install outlet and device boxes and associated covers and fittings of materials and NEMA types suitable for each location and in conformance with the following requirements:

Interior Dry Locations: Sheet steel, NEMA Type 1.

1. Locations Exposed to Weather or Dampness: Cast metal, NEMA type 3R.

2. Wet Locations: NEMA Type 4 enclosures.

3. Corrosive Locations: NEMA Type 4X enclosures.

4. Hazardous (Classified) Locations: NEMA type listed and labeled for the location and class of hazard indicated.

F. Pull and Junction Boxes: Install pull and junction boxes of materials and NEMA types suitable for each location except as otherwise indicated.

G. Floor Boxes: In slabs on grade and wet locations use NEMA type 4 boxes. At other locations in slabs, use concrete-tight NEMA 1 boxes.

3.3 INSTALLATION OF OUTLET BOXES:

A. Outlets at Windows and Doors: Locate close to window trim. For outlets indicated above doors center outlets above the door opening except as otherwise indicated.

B. Column and Pilaster Locations: Locate outlet boxes for switches and receptacles on columns or pilasters so the centers of the columns are clear for future installation of partitions.

C. Locations in Special Finish Materials: For outlet boxes for receptacles and switches mounted in desks or furniture cabinets or in glazed tile, concrete block, marble, brick, stone or wood walls, use rectangular shaped boxes with square corners and straight sides. Install such boxes without plaster rings. Saw cut all recesses for outlet boxes in exposed masonry walls.

D. Gasketed Boxes: At the following locations use malleable or cast metal, threaded hub type boxes with gasketed weatherproof covers:

1. Exterior locations.
2. Where surface mounted on unfinished walls, columns or pilasters. (Cover gaskets may be omitted in dry locations).
3. Where exposed to moisture laden atmosphere.
4. At food preparation equipment within four ft. of steam connections.
5. Where indicated.

E. Mounting: Mount outlet boxes for switches with the long axis vertical or as indicated. Mount boxes for receptacles vertically, except above counter receptacles to be mounted horizontally. Three or more gang boxes shall be mounted with the long axis horizontal. Locate box covers or device plates so they will not span different types of building finishes either vertically or horizontally. Locate boxes for switches near doors on the side opposite the hinges and close to door trim, even though electrical floor plans may show them on hinge side. Provide far side box supports, for electrical switch boxes installed on metal studs and provide stud to stud support for electrical receptacle boxes installed on metal studs.

F. Ceiling Outlets: For fixtures, where wiring is concealed, use outlet boxes 4 inches square by 1-1/2 inches deep, minimum.

G. Cover Plates for Surface Boxes: Use plates sized to box front without overlap.

H. Protect outlet boxes to prevent entrance of plaster, and debris. Thoroughly clean foreign material from boxes before conductors are installed.

I. Concrete Boxes: Use extra deep boxes to permit side conduit entrance without interfering with reinforcing, but do not use such boxes with over 6 inch depth.

J. Floor Boxes: Install in concrete floor slabs so they are completely enveloped in concrete except for the top. Where normal slab thickness will not envelop box as specified above, provide increased thickness of the slab. Provide each compartment of each floor box with grounding terminal consisting of a washer-in-head machine screw, not smaller than no. 10-32, screwed into a tapped hole in the box. Adjust covers of floor boxes flush with finished floor.

K. Existing Outlet Boxes: Where extension rings are required to be installed, drill new mounting holes in the rings to align with the mounting holes on the existing boxes where existing holes are not aligned.

L. Back to back outlet boxes are not permitted. Separate boxes a minimum of 6 inches in standard walls and 24 inches in acoustical walls.

3.4 INSTALLATION OF PULL AND JUNCTION BOXES:

A. Box Selection: For boxes in main feeder conduit runs, use sizes not smaller than 8 inches square by 4 inches deep. Do not exceed 6 entering and 6 leaving raceways in a single box. Quantities of conductors (including equipment grounding conductors) in pull or junction box shall not exceed the following:

Size of Largest Conductors in Box	Maximum no. of Conductors in Box
No. 4/0 AWG	30
250 MCM	20
500 MCM	15
Over 500 MCM	10

B. Cable Supports: Install clamps, grids, or devices to which cables may be secured. Arrange cables so they may be readily identified. Support cable at least every 30 inches inside boxes.

C. Mount pull boxes in inaccessible ceilings with the covers flush with the finished ceiling.

D. Size: Provide pull and junction boxes for telephone, signal, and other systems at least 50 percent larger than would be required by Article 370 of NEC, or as indicated. Locate boxes strategically and provide shapes to permit easy pulling of future wires or cables of types normal for such systems.

3.5 INSTALLATION OF CABINETS AND HINGED DOOR ENCLOSURES:

A. Mount with fronts straight and plumb.

B. Install with tops 78 inches above floor.

C. Set cabinets in finished spaces flush with walls.

3.6 GROUNDING:

A. Electrically ground metallic cabinets, boxes, and enclosures. Where wiring to item includes a grounding conductor, provide a grounding terminal in the interior of the cabinet, box or enclosure.

3.7 CLEANING AND FINISH REPAIR:

A. Upon completion of installation, inspect components. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, abrasions and weld marks.

B. Galvanized Finish: Repair damage using a zinc-rich paint recommended by the tray manufacturer.

C. Painted Finish: Repair damage using matching corrosion inhibiting touch-up coating.

END OF SECTION 260534

SECTION 260553 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY:

A. This Section includes identification of electrical materials, equipment, and installations. It includes requirements for electrical identification components including but not limited to the following:

1. Buried electrical line warnings.
2. Identification labeling for raceways, cables, and conductors.
3. Operational instruction signs.
4. Warning and caution signs.
5. Equipment labels and signs.

1.2 SUBMITTALS:

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Product Data for each type of product specified.

2. Schedule of identification nomenclature to be used for identification signs and labels for each piece of equipment shall include, but not be limited to, the following equipment types as specified in Division 26.

a. Cabinets and enclosures
b. Switchboards and Switchgear
c. Panelboards
d. Disconnect switches
e. Circuit breakers and switches
f. Transfer switches
g. Engine generators and all ancillary cabinets and equipment
h. Fire alarm system panels and all ancillary cabinets and equipment

3. Samples of each color, lettering style and other graphic representation required for identification materials; samples of labels and signs.

4. Identification required in this section shall apply to equipment furnished in Division 26 and any other applicable Divisions including Division 23.

1.3 QUALITY ASSURANCE:

A. ANSI Compliance: Comply with requirements of ANSI Standard A13.1, "Scheme for the Identification of Piping Systems," with regard to type and size of lettering for raceway and cable labels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Ideal Industries, Inc.
2. LEM Products, Inc.
3. Markal Corp.
4. Panduit Corp.
5. W.H.Brady, Co.
6. 3M Company

2.2 ELECTRICAL IDENTIFICATION PRODUCTS:

A. Provide colored Adhesive Marking Tape for banding Wires and Cables: Self-adhesive vinyl tape not less than 3 mils thick by 1 inch to 2 inches in width. Make each color band completely encircling cables, at penetrations of walls and floors, at each junction box and at 20-foot maximum intervals in straight runs.

B. Underground Line Marking Tape: Metal-detector detectable, permanent, bright-colored, continuous-printed, plastic tape compounded for direct-burial service not less than 6 inches wide by 4 mils thick. Printed legend indicative of general type of underground line below.

C. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound, cable/conductor markers with preprinted numbers and letter.

D. Engraved, Plastic-Laminated Labels, Signs and Instruction Plates: Engraving stock melamine plastic laminate, 1/16 inch minimum thick for signs up to 20 square inches, or 8 inches in length; 1/8 inch thick for larger sizes. Engraved legend in white letters on black face for normal and white letters on red face for emergency, black letters on yellow face for UPS and punched for mechanical fasteners. Where required for ground connections, provide engraved legend in white letters on green face.

E. Fasteners for Plastic-Laminated and Metal Signs: Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers.

F. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 0.18-inch minimum width, 50 lb minimum tensile strength, and suitable for a temperature range from minus 50 degrees F to 350 degrees F. Provide ties in specified colors when used for color coding.

G. Adhesive Marking Tape for Device Cover Plates: 3/8 inch Kroy tape or Brother labels with 3/16 inch minimum height letters. Tape shall have black letters on clear background for normal and red letters on clear background for emergency. Embossed Dymo-Tape labels are not acceptable.

PART 3 - EXECUTION

2.3 INSTALLATION:

A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and as required by code.

B. Install identification devices in accordance with manufacturer's written instructions and requirements of NEC.

C. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.

D. Conduit Identification: Label conduits with painted couplings & connectors concealed or with labels at 10 foot intervals (medium voltage or exposed) to identify all conduits run exposed or located above accessible ceilings. Conduits located above non-accessible ceiling or in floors and walls shall be labeled within 3 feet of becoming accessible. Labels for multiple conduits shall be aligned and read the same direction. Use the colors as identified above:

E. Identify Junction, Pull and Connection Boxes: Identification of systems and circuits shall indicate system voltage and identity of contained circuits on outside of box cover. Color code shall be same as conduits for pressure sensitive labels. Use self adhesive marking tape labels at exposed locations and indelible black marker at concealed boxes. All fire alarm boxes shall have covers painted red. All temperature control boxes shall have covers painted blue.

F. Underground Electrical Line Identification: During trench backfilling, for exterior underground power, signal and communications lines, install continuous underground plastic line marker, located directly above line at 6 to 8 inches below finished grade. Where multiple lines installed in a common trench or concrete envelope, do not exceed an overall width of 16 inches; install a single line marker. Tape shall be 6 inches wide, 0.004 inches thick and 1750 psi minimum strength, trace wire run continuous length manhole to manhole and to equipment. Provide 3 feet slack rolled at each end.

1. Install line marker for underground wiring, both direct-buried and in raceway. Red for electrical, orange for phone and cable.

G. Circuit Identification: Tag or label conductors as follows:

1. Future Connections: Conductors indicated to be for future connection or connection under another contract with identification indicating source and circuit numbers.

2. Multiple Circuits: Where multiple branch circuits, control wiring or communications/signal conductors are terminated or spliced in a box or enclosure, label each conductor or cable with circuit number. For control and communications/signal wiring, use wire/cable marking tape at terminations in wiring boxes, troughs and control cabinets. Use consistent letter/number conductor designations throughout on wire/cable marking tapes.

3. Match identification markings with designations used in panelboards shop drawings, Contract Documents, and similar previously established identification schemes for the facility's electrical installations.

H. Apply warning, caution and instruction signs and stencils as follows:

1. Install warning, caution or instruction signs where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed

for system or equipment operation. Install butyrate signs with metal backing for outdoor items.

2. Emergency Operating Signs: Install, where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect, engraved laminate signs with white legend on red background with minimum 3/8 inch high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.

   a. Provide sign at main service entrance switch, indicating type and location of on-site stand-by generator as required by NEC. Sign shall read “Secondary Source Provided by Engine Generator Located ____”.

I. Install equipment/system circuit/device identification as follows:

1. Apply equipment identification labels of engraved plastic-laminate on each major unit of electrical equipment in building, including central or master unit of each electrical system. This includes communication/signal/alarm systems, unless unit is specified with its own self-explanatory identification. Text shall match terminology and numbering of the Contract Documents and shop drawings. Apply labels for each unit of the following categories of electrical equipment.

   a. Panelboards, electrical cabinets and enclosures.
   b. Access doors and panels for concealed electrical items.
   c. Electrical switchgear and switchboards.
   d. Power transfer equipment.
   e. Contactors.
   f. Remote-controlled switches.
   g. Dimmers.
   h. Control devices.
   i. Transformers.
   j. Inverters.
   k. Power generating units.
   l. Fire alarm master station or control panel.

J. Apply circuit/control/item designation labels of engraved plastic laminate for disconnect switches, breakers, pushbuttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components, where labeling is specified elsewhere.

K. For panelboards, provide framed, typed circuit schedules (label all spares and spaces in pencil) with explicit description and identification of items controlled by each individual breaker.

L. Tag all grounding electrode conductors, associated bonding conductors, and grounding conductors at their point of attachment to any ground bus and grounding electrode (where possible) with a 2 inch diameter round green phenolic nameplate. Lettering shall be 1/4 inch high with 1/5 inch between lines centered on the tag stating "DO NOT DISCONNECT," "MAIN GROUND." Nameplate shall attach to conductor with a short length of small chain.

M. Install labels at locations as required and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

N. Provide tape labels for identification of individual receptacle and light switch wallplates. Locate tape on front of plate and identify panel/branch circuit serving the receptacle. Provide tape labels for identification of individual switches or thermal overload switches which serve as equipment disconnects. Locate the tape on the front of the coverplate and identify panel/branch circuit serving the equipment.

END OF SECTION 260553

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SECTION 260583 – WIRING CONNECTIONS

PART 1 GENERAL

1.1 SUMMARY:

A. Extent of electrical connections for equipment is indicated by drawings and schedules. Electrical connections are hereby defined to include connections used for providing electrical power to equipment.

B. Applications of electrical power connections specified in this section include the following:

1. To resistive heaters.
2. From electrical source to motor starters.
3. From motor starters to motors.
4. To lighting equipment.
5. To converters, rectifiers, transformers, inverters, rheostats, and similar current adjustment features of equipment.
6. To grounds including earthing connections.
7. To master units of communication, signal, alarm, clock, public address, sound, and video systems.
8. From push buttons
9. To equipment requiring electrical connection.
10. Other connections as shown.

1.2 QUALITY ASSURANCE:

A. Manufacturers: Firms regularly engaged in manufacture of electrical connectors and terminals, of types and ratings required, and ancillary connection materials, including electrical insulating tape, soldering fluxes, and cable ties, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firms with at least 2 years of successful installation experience with projects utilizing electrical connections for equipment similar to that required for this project.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's data on electrical connections for equipment products and materials.

1.4 DEFINITIONS:

A. Load voltage wiring shall be defined as:

Conduit and wiring required to carry power to motors and other equipment or devices. Wiring from control devices to equipment that carry power to drive that equipment such as line voltage thermostats, etc., shall be included as load voltage wiring. Wiring that provides power to control panels, control transformers, control relays, time clocks, etc., shall also be included as load voltage wiring.

1.5 DELIVERY, STORAGE, AND HANDLING:

A. Deliver electrical connection products wrapped in proper factory fabricated type containers.

B. Store electrical connection products in original cartons and protect from weather, construction traffic and debris.

C. Handle electrical connection products carefully to prevent breakage, denting, and scoring finish.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide circuit and motor disconnects by one of the following:

1. General Electric Co.
2. Eaton
3. Square D Company
4. Siemens Energy & Automation, Inc.
5. Westinghouse Electric Corp.

2.2 GENERAL:

A. Overcurrent Protective Devices (OCPDs): Provide type, rating, and features as indicated. Comply with Division 16 Section on Overcurrent Protective Devices, with OCPDs adapted to equipment connection installation. Tandem circuit breakers shall not be used. Multiple breakers shall have common trip.

B. Provide motor controllers that are horsepower rated to suit the motor controlled.

C. Contacts shall open each ungrounded connection to the motor. Contacts shall be NEMA rated, 75°C.

D. Overload relays shall be ambient-compensated type with inverse-time-current characteristic. Provide with heaters or sensors in each phase matched to nameplate full load current of the specific motor to which connected with appropriate adjustment for duty cycle and power factor correction supplied with the motor.

2.3 MATERIALS AND COMPONENTS:

A. General: For each electrical connection indicated, provide complete assembly of materials, including but not necessarily limited to, pressure connectors, terminals (lugs), electrical insulating tape, electrical solder, electrical soldering flux, heat-shrinkable insulating tubing, cable ties, solderless wire-nuts, disconnect, starter, contactor, relays, etc., and other items and accessories as needed to complete splices and terminations of types indicated.

B. Metal Conduit, Tubing and Fittings:

1. General: Provide metal conduit, tubing and fittings of types, grades, sizes and weights (wall thicknesses) indicated for each type service. Provide products complying with Division-26 section on Raceways.

C. Wires, Cables, and Connectors:

1. General: Provide wires, cables, and connectors complying with Division-26 section on Wires and Cables.

2. Wires/Cables: Unless otherwise indicated, provide wires/cables (conductors) for electrical connections which match, including sizes, ratings, and material of wires/cables which are supplying electrical power.

3. Connectors and Terminals: Provide electrical connectors and terminals which mate and match, including sizes and ratings, with equipment terminals and are recommended by equipment manufacturer for intended applications.

4. Electrical Connection Accessories: Provide electrical insulating tape, heat-shrinkable insulating tubing and boots, electrical solder, electrical soldering flux, wirenuts and cable ties as recommended for use by accessories manufacturers for type services indicated.

5. Cord and Plug Connected Equipment: Where indicated, contractors shall provide a length of SO cord complete with a straight blade or twist-lock receptacle for connection of equipment. Cord and plug rating shall be suitable for the connected equipment load and rating of the branch circuit overcurrent protective device. Plug shall match receptacle configuration included on the plans and cord length shall be as required. Contractor shall connect cord to equipment.

2.4 CIRCUIT AND MOTOR DISCONNECT SWITCHES:

A. General: Provide circuit and motor disconnect switches in types, sizes, duties, features, ratings, and enclosures as indicated. All equipment with maximum fuse size listed in nameplate shall have fusible disconnect switch provided. Provide NEMA 1 enclosure. For outdoor switches and switches indicated as weatherproof, provide NEMA 3R enclosures with raintight hubs. For motor and motor starter disconnects, provide units with horsepower ratings suitable to the loads.

B. Fusible Switches: Provide UL type "HD" 100 percent duty rated switches, with fuses of classes and current ratings indicated. Comply with Division 16 section on Overcurrent Protective Devices. Where current limiting fuses are indicated, provide switches with non-interchangeable feature suitable only for current limiting type fuses. All disconnect switches shall be fusible unless otherwise noted.

C. Non-fusible Disconnects: Provide UL type "HD" 100 percent duty rated switches of classes and current ratings as indicated.

D. Double-Throw Switches: Provide heavy duty switches of classes and current ratings as indicated.

E. Switches for Classified (Hazardous) Locations: Provide heavy duty switches, with UL labels and listings for hazardous location classifications in which installed.

F. Accessories:

1. Electrical Interlocks: Provide number and arrangement of interlock contacts in switches as indicated or required.

2. Special Enclosure Material: Provide special enclosure material as follows for switches indicated:

   a. Stainless Steel Type 304: For NEMA Type 4.
   b. Molded Fiberglass Reinforced Plastic: For NEMA Type 4x.
   c. Heavy Cast Aluminum: For hazardous locations. NEMA Types 7 through 9.

3. Handles shall be lockable in open and closed position without modification.

2.5 AUXILIARY CONTROL DEVICES:

A. General: Provide the following factory installed in controller enclosure except as otherwise indicated. Where separately mounted, provide NEMA 1 enclosure except as otherwise indicated.

1. Pushbutton Stations, Pilot Lights, and Selector Switches: Heavy-duty type. HAND-OFF-AUTOMATIC (H-O-A) switches shall be provided on all magnetic starters. Provide magnetic two-speed starters with a HIGH-LOW selector with H-O-A switch wired to allow manual speed selection in HAND position and remote speed selection in AUTO.
2. Stop and Lockout Pushbutton Station in Motor Control Centers: Momentary-break pushbutton station with a factory-applied hasp arranged so a padlock can be used to lock the pushbutton in the depressed position with the control circuit open.
3. Control Relays: Auxiliary and adjustable time-delay relays as required to coordinate with Division 15 Controls Section.
4. Elapsed Time Meters: Heavy duty with digital readout in hours. Provide on all magnetic starters for motors.
5. Ammeters, Voltmeters, and Frequency Meters: Panel type, 2-1/2 inch minimum size with 90 degree or 120 degree scale and plus or minus 2 percent accuracy. Where indicated, provide transfer device with an off position.
6. Current Sensors: Rated to suit application.
7. Phase-Failure Relay: Provide relay for each motor 2 HP and larger. Relay shall have solid-state sensing circuit with isolated contacts for hard-wired connection to socket. Provide matching pin type relay and hold down clamps. Relay shall be arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage. Provide adjustable response delay, and adjustable undervoltage setting.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Inspect area and conditions under which electrical connections for equipment are to be installed and notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.2 INSTALLATION OF ELECTRICAL CONNECTIONS:

A. Furnish, set in place, and wire (except as may be otherwise indicated) all heating, ventilating, air conditioning, plumbing and fire protection, elevator, etc., motors and controls in accordance with the following schedule and in accordance with equipment manufacturer's written instructions and with recognized industry practices, and complying with applicable requirements of UL, NEC and NECA's "Standard of Installation" to ensure that products fulfill requirements. Carefully coordinate with work performed under the Mechanical Division of these Specifications.

B. Coordinate with other work, including wires/cables, raceway and equipment installation, as necessary to properly interface installation of electrical connections for equipment with other work.

C. Connect electrical power supply conductors to equipment conductors in accordance with equipment manufacturer's written instructions and wiring diagrams. Mate and match conductors of electrical connections for proper interface between electrical power supplies and installed equipment.

D. Maintain existing electrical service and feeders to equipment serving occupied areas and operational facilities, unless otherwise indicated, or when authorized otherwise in writing by Owner, or Architect/Engineer. Provide temporary service during interruptions to existing facilities. When necessary, schedule momentary outages for replacing existing wiring systems with new wiring systems. When that "cutting over" has been successfully accomplished, remove, relocate, or abandon existing wiring as indicated.

E. Cover splices with electrical insulating material equivalent to, or of greater insulation resistivity rating, than electrical insulation rating of those conductors being spliced.

F. Prepare cables and wires, by cutting and stripping covering armor, jacket, and insulation properly to ensure uniform and neat appearance where cables and wires are terminated. Exercise care to avoid cutting through tapes which will remain on conductors. Also avoid "ringing" copper conductors while skinning wire.

G. Trim cables and wires as short as practicable and arrange routing to facilitate inspection, testing and maintenance.

H. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturers published torque tightening values for equipment connectors. Accomplish tightening by utilizing proper torquing tools, including torque screwdriver, beam-type torque wrench, and ratchet wrench with adjustable torque settings. Where manufacturer's torquing requirements are not available, tighten connectors and terminals to comply with torquing values contained in UL's 486A.

I. Install pre-finished cord set where connection with attachment plug is indicated or specified, or use attachment plug with suitable strain-relief clamps.

J. Provide suitable strain relief clamps for cord connection to outlet boxes and equipment connection boxes.

K. Make wiring connections in control panel or in wiring compartment of pre-wired equipment in accordance with manufacturer's instructions. Provide interconnecting wiring where indicated.

L. Install disconnect switches, controllers, control stations, and control devices such as limit switches and temperature switches as indicated or per manufacturer's instructions.

M. Provide each motor with a horsepower rated disconnect switch and external thermal overload protection.

N. Provide circuit and motor disconnect switches as indicated and where required by Code. Comply with switch manufacturers printed installation instructions. Install within sight of motors.

O. All splices in control panels, terminal junction boxes, low voltage control circuits and fire alarm conductors shall be on numbered terminal strip.

P. Each branch circuit serving dedicated, isolated or emergency receptacles, multi-outlet assemblies or equipment connections shall be furnished with a dedicated neutral conductor. Neutrals common to more than one circuit shall only be permitted where specifically noted.

Q. Where conduit is not required, plenum rated cable shall be provided in ceiling, floor or other air plenum spaces.

3.3 FIELD QUALITY CONTROL:

A. Upon completion of installation of electrical connections, and after circuitry has been energized with rated power source, test connections to demonstrate capability and compliance with requirements. Ensure that direction of rotation of each motor fulfills requirement. Correct malfunctioning units at site, then retest to demonstrate compliance.

3.4 EQUIPMENT CONNECTION SCHEDULES:

A. Mechanical Equipment:

1. Refer to Mechanical Equipment Schedule on the drawings.

2. All load voltage wiring shall be provided under Division 26.

3. Unless otherwise indicated, it is suggested that all equipment motors and control shall be furnished, set in place, and wired in accordance with the schedule contained herein. The exact furnishing and installation of the equipment is left to the Contractors involved. Contractor should note that the intent of this schedule is to have the Contractor responsible for coordinating all wiring as outlined, whether or not specifically called for by the Division 23 or Division 26 drawings and specifications. Comply with the applicable requirements of Division 26 for all electrical work which is not otherwise specified. No extras will be allowed for contractor's failure to provide for these required items. Contractor shall refer to the Division 26 and Division 23 specifications and plans for all power and control wiring and shall advise the Architect/Engineer of any discrepancies prior to bidding.

ITEM	FURNISHED BY	SET BY	CONTROL WIRING (non-load voltage)

1. Mechanical Equipment Motors	M	M	--
2. Special Equipment (i.e., elevators, etc.) a. Motors b. Magnetic Motor Starters c. Disconnect Switches Thermal OL Switches Manual Operating Switches	 G G E	 G E* E	 -- -- --
3. Motor Starters, combination motor starter/disconnect and Variable Frequency Drives a. Automatically controlled, with or without HOA switches. b. Manually controlled. c. Starters integral with motor control centers including control relays and transformers. d. Combination Starter/Disconnects	 M M E M	 E* E* E E*	 M -- -- M
4. Pushbutton stations, pilot lights	M	E*	M
5. Disconnect switches, thermal overload switches, manual operating switches.	E	E*	M
6. Multi-speed switches	M	E*	M
7. Control relays, transformers.	M	M	M
8. Load voltage control items such as line voltage thermostats not connected to control panel systems.	M	M	E
9. Non-load voltage control items.	M	M	M
10. Electric thermostats, remote bulb thermostats, motor valves, float controls, etc., which are an integral part of mechanical equipment or directly attached to ducts, pipes, etc.	M	M	M
11. Motor valves, damper motor, solenoid valves, EP and PE switches, VAV box controls, actuators, etc.	M	M	M**
12. Control circuit outlets	E	E	--
13. Fire protection controls (Including flow switches)	M	M	M**
14. Duct smoke detectors, including relays for fan shutdown.	E	M	M**
15. Temperature Control Panel	M	M	M
16. Interlocks	M	M	M

G = General, Division 13 or 14
M = Mechanical, Division 23
E = Electrical, Division 26

* For factory pre-wired equipment specified under other Divisions, all wiring within the equipment shall be by the manufacturer. Connection to the equipment shall be by Division 26, as shown on electrical drawings.

Manufacturer's equipment provided under other divisions which varies from what is shown on Division 26 drawings shall be the responsibility of the Contractor to complete and pay for any costs for those variations.

** Fire alarm system control modules and wiring from fire alarm contacts to fire alarm system under Division 26. See details.

*** Integral control wiring under Electrical Division as manufacturer supplied equipment. Control wiring for automatic control portion under Mechanical Division.

4. Owner Furnished Equipment:

END OF SECTION 260583

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY:

A. This Section includes low-voltage power service and distribution switchboards and associated auxiliary equipment rated 600 V or less.

1.2 SUBMITTALS:

A. Product data for each product and component specified.

B. Shop drawings for each switchboard including dimensioned plans and elevations, component and device lists, and a single-line diagram showing main and branch bus current ratings and continuous and short-circuit ratings of switchboard.

C. Shop drawings or other descriptive documentation of optional barriers specified for electrical insulation and isolation. Show front and side views of enclosures with dimensions.

D. Shop drawings of utility company metering provisions with indication of approval by utility company.

E. Shop drawings of spare fuse cabinet showing material, dimensions, and features including storage provisions for fuse cartons.

F. Schedule of features, characteristics, ratings, and factory settings of individual protective devices.

G. Manufacturer's Schematic Wiring Diagram.

H. Point-to-Point Control Wiring Diagram: Differentiating between manufacturer-installed and field-installed wiring (may be submitted upon delivery of switchboard).

1.3 QUALITY ASSURANCE:

A. Listing and Labeling: Provide switchboard assemblies that are listed and labeled.

1. The terms "listed" and "labeled": As defined in the National Electrical Code, Article 100.

B. Product Selection for Restricted Space: The Drawings indicate maximum dimensions for switchboard equipment including clearances between switchboard and adjacent surfaces and items. Switchboards having equal performance characteristics and complying with indicated maximum dimensions may be considered.

C. Manufacturer's Qualifications: Firms regularly engaged in the manufacture of switchboards, of types, sizes and capacities required, and whose products have been in satisfactory use in similar service for not less than 5 years.

D. Installer's Qualifications: Firm with at least 5 years of successful installation experience on project utilizing switchboard units similar to that required for this project.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Deliver switchboards and components properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory-fabricated handling of heavy items. Utilize factory-fabricated type containers or wrapping for switchboards and components which protect equipment from damage. Inspect equipment to ensure that no damage has occurred during shipment.

B. Deliver in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

C. Store switchboard equipment in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping. Store so condensation will not occur on or in switchboards. Provide temporary heaters as required to assure avoiding condensation.

D. Handle switchboard equipment carefully to prevent physical damage to equipment and components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which would damage the electrical equipment contained therein. Do not install damaged equipment; remove from site and replace damaged equipment with new.

E. Spare Indicating Lamps: Furnish 6 of each type and color installed.

1.5 SEQUENCING AND SCHEDULING:

A. Schedule delivery of switchboard equipment which permits ready building ingress for large equipment components to their designated installation spaces. Coordinate delivery of equipment with the installation of other building components.

B. Coordinate the size and location of concrete equipment pads.

C. Coordinate with other electrical work including raceways, electrical boxes and fittings, and cabling/wiring, as necessary to interface installation of switchboards.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. General Electric Co.
2. Square D Co.
3. Siemens Energy & Automation, Inc.
4. Eaton

B. Metering Equipment:

1. General Electric
2. Square D Co.
3. Siemens Energy & Automation, Inc.

4. ABB Power Distribution, Inc.
5. Eaton
6. Sangamo
7. TESCO

2.2 SWITCHBOARDS, GENERAL:

A. Description: Front-connected, front-accessible, with fixed, individually mounted main device, panel-mounted branches, and sections rear aligned. Dead front, metal enclosed, self supporting and conforming to NEMA PB2.

B. Barriers: Provide Barriers between adjacent switchboard sections.

2.3 FABRICATION AND FEATURES:

A. Enclosure: Steel. NEMA 1.

B. Enclosure Finish for Indoor Units: Manufacture standard gray finish over a rust inhibiting primer on phosphatizing treated metal surface. Provide painted surfaces that conform to IEEE C37.20.1, "Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear."

C. Utility Metering Compartment: Fabricated compartment and section meeting utility company requirements. Where separate vertical section is required for utility metering, match and align with basic switchboard.

1. Provide integral meter base in accordance with utility standards.

D. Bus Transition and Incoming Line Pull Sections: Where required, match and align with basic switchboard. Line terminations shall be accessible from the front of the switchboard.

E. Hinged Front Panels: Provide to allow access to breaker, metering, accessory, and blank compartments.

F. Pull Box on Top of Switchboard: Provide where indicated or where required by installation conditions, and include the following features:

1. Adequate ventilation to maintain air temperature in pull box within same limits as switchboard.

G. Buses and Connections: Three-phase, four-wire except as otherwise indicated. Features as follows:

1. Phase and Neutral Bus Material: Hard-drawn copper, 98 percent conductivity with feeder circuit-breaker line connections. Horizontal cross busses throughout shall be non-tapered – 100 percent rated. Size bus in accordance with NEMA PB2.

2. Contact Surfaces of Buses: Silver plated copper.

3. Main Phase Buses, Neutral Bus, and Equipment Ground Bus: Uniform capacity the entire length of the switchboard main and distribution sections. Provide for future extensions from either end by means of bolt holes or other approved method and

connecting links. Provide for any outgoing or incoming bus or cabling as required for each breaker space (i.e. all spares, spaces, and utilized).

4. Neutral Buses: 100 percent of the ampacity of the phase buses except as indicated and equipped with approved pressure connector terminations for outgoing circuit neutral cables.

5. Provide two bolt CU/AL compression lugs for all incoming and outgoing feeders including neutral and ground connections.

H. Ground Bus: 1/4 inch by 2 inch minimum size, hard-drawn copper of 98 percent conductivity, and equipped with pressure connector terminations for feeder- and branch-circuit ground conductors.

I. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents. Busses shall be bolted with access for future torque maintenance.

J. Provide four (4) spare two-hole lugs for #2 AWG through #4/0 AWG conductors on load side of main circuit breakers.

K. Provide lugs on load side of distribution device (breakers, switches, etc.), including neutral and ground lugs, as shown on the drawings and as necessary to meet or exceed capacity of OCPD.

L. Provide internal bussing to output lugs or bus flange for each spare breaker provided. All spare cells shall be wired complete to match other cells being utilized. Provide output lugs or bus flange for each spare. Provide lugs unless flange is specifically noted.

2.4 OVERCURRENT PROTECTIVE DEVICES (OCPDS):

A. Comply with requirements of Division 26 Section on Overcurrent Protective Devices for types of OCPDs indicated. Provide indicated features, ratings, characteristics, and settings.

B. Future Devices: Where provision for future overcurrent protective devices or space is indicated, equip compartments with mounting brackets, supports, bus connections, and necessary appurtenances, designed for the OCPD types and ampere ratings indicated for future installation of devices.

2.5 OTHER CIRCUIT CONTROL AND PROTECTIVE DEVICES:

A. General: Factory-installed and -tested devices of types listed below, with indicated ratings, settings, and features.

B. Control Power: Where electrically operated/ shunt tripped circuit breakers/or other control power functions are required, provide 120 volt control circuits supplied through secondary disconnect devices from a control power transformer. Include the following features:

1. Control Power Transformers: Dry type. Separate compartments for units larger than 3 KVA and their fuses.
2. Provide two control power transformers in separate compartments with necessary interlocking relays. Connect the primary of each control power transformer at the line

side of the associated main circuit breaker. Connect the 120 volt secondaries through a relay or relays as a control bus.

3. Control Power Fuses: Include primary and secondary fuses for current-limiting and overload protection.
4. Provide control power disconnecting means on line side of transformer.
5. Provide control fuse status indication on front and contacts for remote alarm.

C. Control Wiring: Factory installed, complete with bundling, lacing, and protection, and complying with the following:

1. Flexible Conductors: Use for size No. 8 and smaller and for conductors across hinges, and conductors for interconnections between shipping units.
2. Conductors Sizes: In accordance with NEC for the duty required.
3. All control wiring shall be terminated on labeled power type terminal blocks with ring terminals.
4. Limit cable bundles to 12 cables maximum.

D. Surge Arresters (UL SA rated-category OWXH): Provide distribution class, metal oxide Varistor as specified in IEEE C62.11, "Standards for Metal-Oxide Surge Arresters for AC Power Circuits," or IEEE C62.1 "Gapped Silicon-Carbide Surge Arresters for Alternating Current Power Circuits." Install in the service entrance cable termination compartment and connect in each phase of each incoming circuit. Coordinate rating with circuit voltage.

1. Description: Coordinate impulse sparkover voltage with system circuit voltage, and provide factory mounting and connection.

E. SPD: Provide surge protective device for switchboard.

2.6 INSTRUMENTATION:

A. Provide the items specified below and mount within utility metering compartment or on front cover of associated breaker.

1. Instrument Transformers: NEMA Standard EI 21.1, "Instrument Transformers for Revenue Metering 110 kV BIL and Less," IEEE Standard C57.13, "Requirements for Instrument Transformers," and the following:

a. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.

b. Current Transformers: Ratios and accuracy class suitable for connected relays, meters, and instruments.

2. Electronic Circuit Monitor: Provide multi-function digital instrumentation mounted on switchboard for main bus and for each branch breaker connection which contains the following functions:

a. REAL TIME Readings:

1) Current (Per Phase, N, G, 3X)
2) Voltage (L-L, L-N)

3) Real Power (Per Phase, 3-phase)
4) Reactive Power (Per Phase, 3-phase)
5) Apparent Power (Per Phase, 3-phase)
6) Power Factor (Per Phase, 3-phase)
7) Frequency
8) THD (Current and Voltage)

b. Demand Readings (Maximum power demand over a 15 minute period continuously recorded over a minimum 30 day period per NEC):

1) Demand-Current (Per Phase Present, Peak)
2) Demand-Real Power (3-phase total) (KWD)
3) Demand-Reactive Power (3-phase Total) (KVARD)
4) Demand Apparent Power (3-phase Total) (KVAD)

c. Energy Readings:

1) Real energy
2) Reactive Energy
3) Apparent Energy
4) Energy Accumulation (Signed, Absolute, Energy-In and Energy-Out)
5) KYZ Output.

d. The circuit monitor shall be capable of interfacing with a personal computer and other monitors. Provide all interface software and a communication port cable.

e. UL 508 listed.

3. Watt-Hour Meter: Flush or semiflush type, rated 5 amperes, 120 V, 3 phase, 3 wire, with 3 elements, 15-minute-indicating-demand register and provision for testing and adding pulse initiation.

2.7 RATINGS:

A. Provide nominal system voltage, continuous main bus amperage, and short-circuit-current ratings as indicated on the drawings.

2.8 ACCESSORY COMPONENTS AND FEATURES:

A. Spare Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented, steel box or cabinet. Arrange for wall mounting.

2.9 IDENTIFICATION:

A. General: Refer to Division 26 section on Electrical Identification. Identify units, devices, controls, and wiring with factory-applied labels and signs.

B. Compartment Nameplates: Engraved laminated plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws.

C. UL nameplates shall be provided for all switchboards. Information shall include, but not be limited to, manufacturer, model number, serial number, plant or manufacturing location, ampere rating, voltage rating, wire and phase identification and bus short circuit bracing rating.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. General: Install switchboards and accessory items in accordance with manufacturers' written installation instructions and the following specifications:

B. Anchor each switchboard assembly to the leveled concrete base in accordance with manufacturer's recommendations. Attach by bolting using minimum of 3/8 inch bolts. Meet appropriate seismic zone requirements.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Operating Instructions: Frame and mount printed, basic operating instructions. Include building main one line diagram for switchboards, including control and key interlocking sequences, and emergency procedures. Include building main one-line diagram. Fabricate frame and cover with clear acrylic plastic. Frame shall be open at the tope for easy removal of drawings for use and updating. Mount on the front of the switchboards.

3.2 IDENTIFICATION:

A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 section on Electrical Identification.

3.3 GROUNDING:

A. Connections: As indicated. Tighten connections to comply with tightening torques specified in UL 486A and 486B.

3.4 CONNECTIONS:

A. Tighten switchboard bus joint bolts and electrical connector and terminal bolts in accordance with manufacturer's published torque-tightening values. Where manufacturer's torque values are not stated, use those specified in UL 486A for copper and UL 486B for aluminum.

3.5 FIELD QUALITY CONTROL:

A. General: Comply with applicable standards of the National Electrical Testing Association (NETA) including Standard ATS, "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems."

B. Manufacturers Field Testing and Start-Up: Manufacturer shall have NETA certified technician perform the following quality control testing, visual and mechanical inspections, electrical tests, and tests of the switchboard.

1. Pretesting: Upon completing installation of the system, perform manufacturer's recommended testing, NETA testing, and the following preparations for tests:

    a. Make insulation resistance tests of connecting supply, feeder and control circuits.

    b. Make continuity tests of circuits.

    c. Provide set of Record Documents. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents.

    d. Provide manufacturer's instructions for installation and testing of switchboard assembly to Owner and Engineer.

    e. Visual inspection of all factory and field wiring for proper live bus clearance and secured for fault currents.

2. Quality Control Testing Program: Conform to the following:

    a. Test Objectives: To assure switchboard installation meets specified requirements, is operational within specified tolerances, provides appropriate protection for system and equipment, and is suitable for energizing.

    b. Procedures: Make field tests and inspections and prepare switchboard assemblies for satisfactory operation in accordance with NETA Standard ATS ("Acceptance Testing Specifications for Electrical Power, Distribution Equipment and Systems") applicable IEEE standards, manufacturer's recommendations, and these specifications.

    c. Schedule tests and provide notification at least one week in advance of test commencement.

    d. Reports: Prepare written reports of test results and observations. Report defective materials and workmanship. Include complete records of repairs and adjustments.

    e. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicated test results, date, and responsible person and organization.

    f. Visual and Mechanical Inspection: Include the following inspections and related work:

        1) Inspect, for defects and physical damage, testing laboratory labels and nameplate compliance with current single-line diagrams. Verify smooth and proper operation of all doors, hinges, handles, latches, etc. Correct or replace as determined necessary by the Owner/Engineer.

        2) Verify that current transformers, potential transformers, and fuses meet specified requirements. Verify relays, meters, and instrumentation are checked and all connections are made properly. Introduce accurately

metered currents and/or voltages to relays and other devices which will enable accurate determination of the tripping or activation characteristics.

3) Perform mechanical operational tests in accordance with manufacturer's instruction manual. Manually exercise each operating mechanism, switches, circuit breakers, etc.

4) Check anchorage, area clearances, and alignment and fit of components in compartments. Verify switchboard, switchboard supports and attachments are designed and installed for appropriate seismic zone.

5) Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.

6) Clean switchboard assembly using manufacturer's approved methods and materials.

g. Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:

1) Insulation resistance test of buses and portions of control wiring that disconnect from solid-state devices through normal disconnecting features. Insulation resistance less than 100 megohms is not acceptable. Tests shall be made phase to phase, phase to neutral, and phase to ground with switches in the open and closed positions.

2) Ratio and polarity tests on current and voltage transformers, not integral with overcurrent protective devices.

3) Ground resistance test on system and equipment ground connections.

4) Calibration of ammeters and voltmeters at midscale.

5) Verify appropriate capacity, overcurrent protection, and operating voltage of control power elements including control power transformer and control power wiring.

6) Calibrate watthour and demand meters to 0.5 percent, and verify meter multipliers.

7) Provide operational test of each automatic breaker, alarm and indication. Provide manual tests initially and proceed to full automatic testing that tests each manual and automatic function, sequence and scenario. Verify and document each sequence including interlock, relay, etc. operation.

8) Tests of Overcurrent Protective Devices: Testing of overcurrent protective devices shall be conducted according to procedures outlined in overcurrent protective devices specification section.

9) Provide complete individual and system testing of ground fault devices and system.

h. Retesting: Correct deficiencies identified by tests and observations and retest switchboards. Verify by the retests that switchboards meet specified requirements.

3.6 CLEANING:

A. Upon completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

3.7 PROTECTION:

A. Temporary Heating: Apply temporary heat in accordance with manufacturer's recommendation within each section of switchboards throughout periods during which the switchboard is not in a space that is continuously under normal control of temperature and humidity.

3.8 DEMONSTRATION:

A. Training: Arrange and pay for the services of factory-authorized service representatives to demonstrate and test switchboards and train Owner's maintenance personnel. Conduct a minimum of one day of training in operation and maintenance as required under Division 1 Section on Project Closeout. Include both classroom training and hands-on equipment operation and maintenance procedures. Record training on disk and turn training disk over with O & M Manuals.

Schedule training with at least seven days advance notification.

END OF SECTION 262413

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SECTION 262416 PANELBOARDS

PART 1 GENERAL

1.1 SUMMARY:

A. This Section includes lighting and power panelboards and associated auxiliary equipment rated 600 V or less.

1.2 DEFINITIONS:

A. Overcurrent Protective Device (OCPD): A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.

1.3 SUBMITTALS:

A. Product data for each type panelboard, accessory item, and component specified.

B. Shop drawings from manufacturers of panelboards including dimensioned plans, sections, and elevations. Show tabulations of installed devices, major features, and voltage rating. Include the following:

1. Enclosure type with details for types other than NEMA Type 1.
2. Bus configuration and current ratings.
3. Short-circuit current rating of panelboard.
4. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.

C. Wiring diagrams detailing schematic diagram including control wiring, and differentiating between manufacturer-installed and field-installed wiring.

D. Report of field tests and observations.

1.4 QUALITY ASSURANCE:

A. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.

B. Manufacturer's Qualifications: Firms regularly engaged in manufacture of panelboards and enclosures, of types, sizes and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.

C. Installer's Qualifications: A firm with at least 3 years of successful installation experience on projects utilizing panelboards similar to those required for this project.

1.5 EXTRA MATERIALS:

A. Keys: Furnish six spares of each type for panelboard cabinet locks.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. General Electric Co.
2. Square D Co.
3. Siemens Energy & Automation, Inc.
4. Eaton

2.2 PANELBOARDS, GENERAL REQUIREMENTS:

A. Overcurrent Protective Devices (OCPDs): Provide type, rating, and features as indicated. Comply with Division 26 Section on Overcurrent Protective Devices, with OCPDs adapted to panelboard installation. Tandem circuit breakers shall not be used. Multiple breakers shall have common trip.

B. Enclosures: Cabinets, flush or surface mounted as indicated. NEMA Type 1 enclosure, except where the following enclosure requirements are indicated. Provide galvanized sheet steel cabinet type enclosures, in sizes and NEMA types as indicated, code-gauge, minimum 16-gauge thickness. Construct with multiple knockouts and wiring gutters. Provide baked gray enamel finish over a rust inhibitor coating. Design enclosures for recessed mounting. Provide enclosures which are fabricated by same manufacturer as panelboards, which mate and match properly with panelboards to be enclosed.

1. NEMA 3R: Raintight
2. NEMA 3S: Raintight and dust tight.
3. NEMA 4X: Corrosion-resistant fiberglass enclosure, watertight, dust tight and resistant to oil and coolant seepage.
4. NEMA 12: Dust tight, dripproof, and resistant to oil and coolant seepage.

C. Front: Hinged trim type, secured to box with 1/4-20-large head slotted captive screws except as indicated. Front for surface-mounted panels shall be same dimensions as box. Fronts for flush panels shall overlap box except as otherwise specified. Provide fronts with hinged trim construction and door with flush locks and keys, all panelboard enclosures keyed alike, with concealed door hinges on inner door, piano hinge on outer trim door, and door swings as indicated.

D. Directory Frame: Metal, mounted inside each panel door with card and clear plastic cover. Directory shall match panelboard configuration, i.e. top to bottom, left to right. Provide permanent panelboard labels for each circuit number.

E. Bus Material: Provide tin plated hard-drawn copper of 98 percent conductivity.

F. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors. Bonded to box.

G. Provide copper lugs for incoming feeders and grounds.

H. Service Equipment Approval: Listed for use as service equipment for panelboards having main service disconnect.

I. Provide minimum short circuit current ratings as indicated.

J. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances, for the OCPD ampere ratings indicated for future installation of devices.

K. Special Features: Provide the following features for panelboards as indicated.

1. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors; insulated from box to be supplied where indicated.

2. Split Bus: Vertical bus of indicated panels divided into two vertical sections with connections as indicated.

3. Contactors in Mains: Mechanically held, with current rating, poles, and connections as indicated. Conform to Division 26 Section "Motor Controller," except omit overload protection.

4. Control Power Source: Control power transformer of capacity indicated, for contactor shunt trip or other devices. Mount in cabinet of panel indicated. Protect primary with current-limiting OCPD as indicated. Provide fused protection of control circuits.

5. Extra Gutter Space: Dimensions and arrangement as indicated or required.

6. Gutter Barrier: Arranged to isolate section of gutter as indicated.

7. Column-Type Panelboard Configuration: Narrow cabinet extended as wireway to overhead junction box equipped with ground and neutral terminal buses.

8. Auxiliary Gutter: Conform to UL 870, "Wireways, Auxiliary Gutters and Associated Fittings."

9. Subfeed: OCPD or lug provision as indicated.

10. Feed-Through Lugs: Sized to accommodate feeders indicated.

L. Branch OCPDs: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

M. Double-Width Panels: Where more than 42 poles are indicated, provide two panelboards of equal dimensions and with individual fronts on each panelboard.

2.3 IDENTIFICATION:

A. General: Refer to Division 26 Section on electrical identification for labeling materials.

B. UL nameplates shall be provided for all panelboards. Information shall include, but not be limited to, manufacturer, model number, serial number, plant or manufacturing location, ampere rating, voltage rating, wire and phase identification and bus short circuit bracing rating.

PART 3 EXECUTION

3.1 INSTALLATION:

A. General: Install panelboards and accessory items in accordance with NEMA PB 1.1, "General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less" and manufacturers' written installation instructions.

B. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289, "Application Guide for Ground Fault Circuit Interrupters."

C. Mounting: Plumb and rigid without distortion of box. Mount flush panels uniformly flush with wall finish.

D. Circuit Directory: Typed and reflective of final circuit changes required to balance panel loads. Obtain approval before installing.

E. Install filler plates in unused spaces.

F. Provision for Future Circuits at Flush Panelboards: Stub one 1 inch empty conduit from panel for each set of 3 spares or spaces into accessible ceiling space or space designated to be ceiling space in future. Stub one 1 inch empty conduits for each set of 3 spares or spaces into raised floor space or below slab other than slabs on grade.

G. Auxiliary Gutter: Install where two panels are vertically mounted. Use gutter for branch circuit wiring to lower panel.

H. Wiring in Panel Gutters: Train conductors neatly in groups, bundle, and wrap with wire ties after completion of load balancing.

3.2 IDENTIFICATION:

A. Identify field-installed wiring and components and provide warning signs in accordance with Division 26 Section on electrical identification.

3.3 GROUNDING:

A. Connections: Make equipment grounding connections for panelboards as indicated.

B. Provide ground continuity to main electrical ground bus indicated.

3.4 CONNECTIONS:

A. Tighten electrical connectors and terminals, including grounding connections, in accordance with manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL:

A. Upon completing installation of the system, perform the following tests:

1. Make insulation resistance tests of panelboard buses, components, and connecting supply, feeder, and control circuits.

2. Make continuity tests of circuits.

B. Procedures: Make field tests and inspections and prepare panelboard for satisfactory operation in accordance with manufacturer's recommendations and these specifications.

C. Schedule tests with at least one week in advance notification.

D. Reports: Provide report written reports of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include records of repairs and adjustments made.

E. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicating results of tests and inspections, responsible organization and person, and date.

F. Visual and Mechanical Inspection: Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.

2. Exercise and perform of operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.

3. Check panelboard mounting, area clearances, and alignment and fit of components.

4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.

5. Verify that proper grounding bushings/bonding/ and panel enclosure bonding is complete.

6. Verify isolated neutral bar and neutral connections.

G. Electrical tests: Include the following items performed in accordance with manufacturer's instruction:

1. Insulation resistance test of buses. Insulation resistance less than 100 megohms is not acceptable.

2. Ground resistance test on system and equipment ground connections.

3. Test main and subfeed overcurrent protective devices in accordance with Section "Overcurrent Protective Devices."

H. Retest: Correct deficiencies identified by tests and observations and provide retesting of panelboards by testing organization. Verify by the system tests that the total assembly meets specified requirements.

3.6 CLEANING:

A. Upon completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marks of finish to match original finish.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY:

A. The extent of wiring device work is indicated by drawings and schedules. Wiring devices are defined as single discrete units of electrical distribution systems which are intended to carry but not utilize electric energy.

B. Types of electrical wiring devices in this section include the following:

1. Receptacles.

2. Ground-fault circuit interrupters.

3. Switches.

4. Wallplates.

5. Dimmers.

6. Plugs and connectors.

1.2 QUALITY ASSURANCE:

A. Manufacturers: Firms regularly engaged in manufacture of electrical wiring devices, of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Installer's Qualifications: Firm with at least 2 years of successful installation experience on projects utilizing wiring devices similar to those required for this project.

C. Listing and Labeling: Provide products that are listed and labeled for their applications and installation conditions and for the environments in which installed.

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

2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's data on electrical wiring devices.

B. Samples of device plates for color selection and evaluation of technical features shall be submitted.

C. Operation and maintenance data for materials and products specified in this Section to include in the "Operating and Maintenance Manual" specified in Division 1.

1.4 COORDINATION:

A. Wiring Devices for Owner Furnished Equipment: Match devices to plug connectors for Owner-furnished equipment.

B. Cord and Plug sets: Match cord and plug sets to equipment requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Manufacturers: Subject to compliance with requirements, provide wiring devices of one of the following:

1. Devices:

a. Harvey Hubbell Inc.
b. Leviton Mfg Co.
c. Pass and Seymour Inc.
d. Cooper Crouse-Hinds Co.
e. Bryant Electric Co.
f. General Electric Co.

2. Wiring Devices for Hazardous (Classified) Locations:

a. Crouse-Hinds Electrical Construction.
b. Killark Electrical Mfg. Co.
c. Pyle-National Co.

2.2 WIRING DEVICES:

A. Receptacles:

1. All duplex, single, and special receptacles shall be minimum, specification grade commercial series, listed by Underwriter's Laboratories, UL 498 and Federal Specification FS W-C-596, 20 amp, nylon face and have a metal mounting strap with self-grounding and have a hex-head green grounding screw and be side and back wired. Each device shall bear the UL/FS Label.

a. Each device shall have terminal screws and clamps listed for use with stranded wire.

2. Convenience Receptacle Configuration: NEMA WD-1 and WD-6; Type 5-20R, with COLOR BY ARCHITECT. Color selection shall be verified with Architect/Engineer prior to ordering.

3. Specific-use Receptacle Configuration: NEMA WD-1 and WD-6 straight blade OR WD 5 locking; as indicated on drawings, black face.

4. Tamper Resistant Receptacles: Duplex receptacle with integral switch and contacts to prevent energization unless a plug is inserted. Install where required by code.

5. Ground-Fault Interrupter Receptacles: Provide "local reset" ground-fault circuit interrupters. Provide unit capable of being installed in a 2-3/4" deep outlet box without adapter, grounding type, Class A, Group 1 per UL Standard 943.

6. Receptacles, Industrial Heavy-Duty: Conform to NEMA Standard PK 4 "Plugs, Receptacles, and cable Connectors of the Pin and Sleeve Type for Industrial Use."

7. Receptacles in Hazardous (Classified) Locations: Comply with NEMA Standard FB 11 "Plugs, Receptacles and Connectors on the Pin and Sleeve Type for Hazardous Locations" and Ul Standard 1010 "Receptacle-Plug Combinations for Use in Hazardous (Classified locations."

8. Pendant Cord/Connector Devices: Matching, locking type, plug and plug receptacle body connector, NEMA l5-20P and L5-20R, heavy-duty grade.

   a. Bodies: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.

   b. External Cable Grip: Woven wire mesh type made of high strength galvanized-steel wire strand and matched to cable diameter and with attached provision designed for the corresponding connector.

9. Cord and Plug Sets: Match voltage and current ratings and number of conductors to requirements of the equipment being connected.

   a. Cord: Rubber-insulated, stranded copper conductors, with type-SOW-A jacket. Grounding conductor has green insulation. Ampacity is equipment rating plus 30% minimum.

   b. Plug: Male configuration with nylon body and integral cable-clamping jaws. Match to cord and to receptacle type intended for connection.

B. Switches:

1. Wall Switches for Lighting Circuits: NEMA WD1 and WD-6; FS W-S-896E; AC quiet type specification grade commercial series listed by Underwriter's Laboratories with toggle handle, rated 20 amperes at 120-277 volts AC, unless noted otherwise. Mounting straps shall be metal and be equipped with a green hex-head ground screw. Each switch shall bear the UL/FS Label.

   a. Each device shall have terminal screws and clamps listed for use with stranded wire.

2. Handle: Ivory for normal power circuits. Verify color with Architect/Engineer prior to ordering.

3. Pilot Light Type: Lighted handle lit when switch is "on."

4. Locator Type: Continuously lighted handle.

5. Switches in Hazardous (Classified) Locations: Comply with UL Standard 894, "Switches for Use in Hazardous (Classified) Locations."

C. Combination Devices: Provide heavy-duty quiet type switch, 20-amperes, 120-277 volts AC, with toggle switch handle, and 3-wire grounding receptacle, 20-amperes, 120- volts, in a common 4 inch square box.

2.3 WIRING DEVICE ACCESSORIES:

A. Wallplates: Provide wallplates for single and combination wiring devices, of types, sizes, and with ganging and cutouts as indicated. Select plates which mate and match wiring devices to which attached. Construct with metal screws for securing plates to devices; screw heads colored to match finish of plates. Identify all wall plates used for receptacles with branch circuit number per requirements of section on Electrical Identification. Provide blank wall plates for all cable, data, telephone and junction and outlet boxes. Where cables are routed through the wallplate, provide grommets in wallplate openings to protect cables. Provide plates possessing the following additional construction features:

1. Material and Finish: 0.04" thick, type 302 satin finished stainless steel.

2. Material and Finish: Steel plate, galvanized for use in unfinished areas, mechanical, and electrical rooms.

PART 3 - EXECUTION

3.1 INSTALLATION OF WIRING DEVICES:

A. Install wiring devices as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices to fulfill project requirements.

B. Coordinate with other work, including painting, electrical boxes and wiring work, as necessary to interface installation of wiring devices with other work.

C. Install wiring devices only in electrical boxes which are clean; free from excess building materials, dirt, and debris.

D. Install wiring devices after wiring work is completed.

E. Install wallplates after painting work is completed.

F. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Stds 486A.

G. Provide GFCI type outlets for each above counter duplex receptacle shown within 6 feet-0 inches of sinks/lavatories. For above counter multi-outlet assemblies which do not contain duplex receptacles that can be replaced with GFCI devices, provide GFI circuit breakers on the branch circuit(s) feeding the assembly.

H. Provide safety type receptacles in all waiting areas and play rooms.

I. Provide GFCI receptacles throughout in kitchens and at vending machines.

3.2 PROTECTION OF WALLPLATES AND RECEPTACLES:

A. Upon installation of wallplates and receptacles, advise Contractor regarding proper and cautious use of convenience outlets. At time of Substantial Completion, replace those items which have been damaged, including those burned and scored by faulty plugs.

3.3 GROUNDING:

A. Provide equipment grounding connections for wiring devices, unless otherwise indicated. Tighten connections to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounds.

3.4 CLEANING:

A. Internally clean devices, device outlet boxes and enclosures. Replace stained, cracked, damaged or improperly painted wall plates or devices. Remove temporary markings of labels.

3.5 TESTING:

A. Prior to energizing circuitry, test wiring for electrical continuity, and for short-circuits. Ensure proper polarity of connections is maintained and prepare test reports. Subsequent to energization, test wiring devices to demonstrate compliance with requirements. Operate each operable device at least six (6) times.

1. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices or similar problems.

2. Tests for Convenience Receptacles:

a. Line Voltage: Acceptable range is 105 to 130 V.

b. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.

c. Ground Impedance: Values of up to 2 ohms are acceptable.

d. Polarity: Test for correct neutral conduct to neutral terminal connection.

e. Using the test plug, verify that the device and its outlet box are securely mounted.

f. GFCI Receptacles: Test for tripping values specified in UL 1436 and UL 943. Test with both local and remote fault simulations in accordance with manufacturing recommendations.

B. Correct Deficiencies and Report:

1. Correct unsatisfactory conditions and retest to demonstrate compliance; replace devices as required to bring system into compliance.

2. Correct malfunctioning units on-site, where possible and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Prepare a report that identifies enclosure, units, conductors and devices checked and describe results. Include notation of deficiencies detected, remedial action taken, and observations and test results after remedial action.

END OF SECTION 262726

SECTION 262800 - LOW-VOLTAGE CIRCUIT PROTECTIVE DEVICES

PART 1 GENERAL

1.1 SUMMARY:

A. This section includes overcurrent protective devices (OCPD's) rated 600 V and below and switching devices commonly used with them.

B. Panelboards and Switchboards: Application, installation, and other related requirements for overcurrent protective device installations in distribution equipment are specified in other Division 26 sections.

1.2 DEFINITIONS:

A. Overcurrent Protective Device (OCPD): A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.

B. Ampere-Squared-Seconds: An expression of available thermal energy resulting from current flow. With regard to current-limiting fuses and circuit breakers, the ampere-squared-seconds during fault current interruption represents the energy allowed to flow before the fuse or breaker interrupts the fault current within its current limiting range.

1.3 SUBMITTALS:

A. Product data for fuses, fusible switches, circuit breakers, and OCPD accessories specified in this Section, including descriptive data and time-current curves for all protective devices and let-through current curves for those with current limiting characteristics. Include coordination charts and tables and related data.

B. Provide coordination study / Arc Flash analysis accordance with ANSI/IEEE Standard 242-1986, "Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems." Submit a full coordination study showing graphically that the substitute OCPD's coordinate selectively with both upstream and downstream components. Include single line diagram, coordinated time-current characteristics, device performance curves, and fault current calculations adequate to demonstrate satisfactory component protection and selective coordination of protective devices. Include Arc Flash Analysis. Submit study with switchgear, switchboard and panelboard submittals

1.4 QUALITY ASSURANCE:

A. Manufacturers: Firms regularly engaged in manufacture of overcurrent protective devices of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Each type of OCPD shall be the product of a single manufacturer.

PART 2 PRODUCTS:

2.1 MANUFACTURERS:

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

1. Cartridge Fuses:

   a. Bussmann Div., Cooper Industries, Inc.
   b. Littelfuse Inc.

2. Fusible Switches:

   a. General Electric Co.
   b. Square D Co.
   c. Allen-Bradley Co.
   d. Siemens Energy & Automation, Inc.
   e. Eaton

3. Molded-Case Circuit Breakers:

   a. Square D Co.
   b. General Electric Co.
   c. Siemens Energy & Automation, Inc.
   d. Eaton

4. When mounting overcurrent protective devices in switchboards, switchgear, panelboards, MCC's, etc., provide equipment of same manufacturer as equipment into which they are being mounted.

2.2 OVERCURRENT PROTECTIVE DEVICES (OCPDS), GENERAL:

A. General: Provide OCPDs in indicated types, as integral components of panelboards, switchboards, motor control centers, and other related equipment; and also as individually enclosed and mounted single units.

B. Enclosures: NEMA 250 "Enclosures for Electrical Equipment (1,000 Volts Maximum)."

C. Where OCPD's are to be installed in existing panelboards, switchboards, and motor control centers, they shall be of the same manufacture and type as those existing in the equipment. If this is not possible, provide devices which are compatible with the existing equipment and when installed will not void the U.L. label or reduce the short circuit rating of the equipment.

D. All overcurrent devices shall be individually rated for the available fault current unless otherwise noted. Series ratings of equipment will only be allowed where specifically called out.

2.3 CARTRIDGE FUSES:

A. General: NEMA Standard FU1, "Low-Voltage Cartridge Fuses." Unless indicated otherwise, provide nonrenewable cartridge fuses of indicated types, classes, and current ratings that have voltage ratings consistent with the circuits on which used.

B. All fuses used for main, feeder, or branch-circuit protection shall be Underwriters Laboratories listed, current-limiting fuses with 200,000 ampere interrupting rating and shall be

so labeled. Fuses used for supplementary protection (other than branch circuit protection) shall be as specified above or shall be U.L. approved or component recognized for such purposes. All fuses provided shall be furnished by the same manufacturer. Should equipment provided require a different U.L. Class or size of fuse, the engineer shall be furnished sufficient data to ascertain that system function will not be adversely affected.

C. In order to simplify fuse replacement, reduce spare fuse inventory and insure adequate thermal protection, all fuses 600 amperes and below shall be true dual-element time-delay fuses with separate spring-loaded thermal overload elements in all ampere ratings. All ampere ratings shall be designed to open at 400 degrees F or less when subjected to a non-load oven test.

D. To eliminate induction heating, all fuse ferrules and end caps shall be non-ferrous and shall be bronze or other alloy not subject to stress cracking.

E. Class L Fuses: UL 198C, "High-Interrupting Capacity Fuses, Current-Limiting Type."

F. Class RK1 Dual Element Time-Delay Fuses: UL 198E, "Class R Fuses."

G. Class J Low-Peak dual Element Fuse: UL 198C

2.4 NONFUSIBLE SWITCHES:

A. General: UL 98 "Enclosed and Dead Front Switches" and NEMA KS 1 "Enclosed Switches," quick-make, quick-break heavy-duty units.

B. Rating: Load-breaking capacity in excess of the normal horsepower rating for the switch.

C. Withstand Capability: In excess of the available.

D. Operation: By means of external handle.

E. Interlock: Prevents access to switch interior except when in "off" position.

F. Enclosure for Independent Mounting: NEMA Type 1 enclosure except as otherwise indicated or required to suit environment where located.

G. Contacts shall be NEMA rated 75 degrees C.

H. Provide auxiliary contacts for disconnects supplied from variable frequency drives.

2.5 FUSIBLE SWITCHES:

A. General: UL 98 "Enclosed and Dead Front Switches" and NEMA KS 1 "Enclosed Switches," quick-make, quick-break heavy-duty units.

B. Rating: Load-breaking capacity in excess of the normal horsepower rating for the switch.

C. Withstand Capability: In excess of the let-through current permitted by its fuse when subject to faults up to 100,000 RMS symmetrical amperes.

D. Operation: By means of external handle.

E. Interlock: Prevents access to switch interior except when in "off" position.

F. Fuse Clips: Rejection type.

G. Enclosure for Switchboard or Panel board Mounting: Suitable for panel mounting where indicated.

H. Enclosure for Independent Mounting: Provide NEMA Type 1 enclosure except as otherwise indicated or required to suit environment where located.

I. Contacts shall be NEMA rated 75 degrees C.

J. Provide fuses for safety switches and other equipment of classes, types, and rating needed to fulfill electrical requirements for services indicated.

K. Provide auxiliary contacts for disconnects supplied from variable frequency drives.

2.6 MOLDED-CASE CIRCUIT BREAKERS:

A. General: UL 489, "Molded Case Circuit Breakers and Circuit Breaker Enclosures," and NEMA AB 1, "Molded Case Circuit Breakers."

B. Construction: Provide bolt-in type, except breakers 225-ampere frame size and larger which may be plug-in type if held in place by positive locking device requiring mechanical release for removal.

C. Characteristics: Indicated frame size, trip rating, number of poles, and a short-circuit interrupting capacity rating as indicated or required to match existing devices or equipment.

D. Tripping Device: Quick-make, quick-break toggle mechanism with inverse-time delay and instantaneous overcurrent trip protection for each pole. Trip unit to be interchangeable within frame sizes for breakers 200 amperes or larger. Breakers 150 amperes and above shall have adjustable trip selection for trip units. All 120/208 volt rated breakers shall be rated and labeled "High Magnetic".

D. Adjustable Instantaneous Trip Devices: Factory adjusted to low-trip-setting current values. Provide adjustable instantaneous trip devices for each circuit breaker supplying individual motor loads and where indicated.

E. Enclosure for Switchboard or Panelboard Mounting: Suitable for panel mounting in switchboard or panelboards where indicated.

F. Enclosure for Switchboard or Motor Control Center Mounting: Provide individual mounting where indicated.

G. Enclosure for Independent Mounting: NEMA Type 1 enclosure, except as otherwise indicated or required to suit environment where located.

2.7 CIRCUIT BREAKERS WITH SOLID-STATE TRIP DEVICES:

A. General: Provide 250 amp frame size and larger circuit breakers with solid-state trip devices having the following features:

1. Ambient Compensation: Trip device insensitive to temperature changes between minus 20 degrees C and plus 55 degrees C.

2. Adjustability: Breaker ratings and trip settings shall be changeable by operation of controls on front panel of breaker and by change of plug-in element without removing the breaker.

a. The trip device sensor shall have the same rating as the frame amperage of the circuit breaker unless noted otherwise.

3. Ground-Fault Tripping: Provide adjustable pick-up and time-delay on circuit breakers indicated with GFI.

4. Provide zone-selective interlocking capability with both short-time and ground-fault interlock on circuit breakers indicated with Z.

2.8 OCPD ACCESSORIES:

A. Key Interlocks: Arrange interlocking so keys are held captive at devices indicated. Where future key interlocking provisions are indicated, provide necessary mountings and hardware as required for the future installation.

B. Provide adjustable-time-delay under-voltage trip devices where indicated.

C. Provide shunt-trip devices for Circuit breakers unless otherwise indicated. Arrange to trip breaker from an external source of power through a control switch or relay contact.

D. Provide bell alarm contacts for tripped position.

E. Lock-Out Devices: Provide padlocking provisions on each overcurrent protective device, lockable in the open or closed position to meet NEC requirements. Provide 3 sets of lockout/tagout devices for each type of breaker or switch provided. Include tags, locks and all accessories necessary.

F. Provide hand held battery powered trip unit power supply with labeled storage compartment for each switchboard.

PART 3 - EXECUTION:

3.1 INSTALLATION:

A. Independently Mounted OCPDs: Locate as indicated and install in accordance with manufacturer's written installation instructions. Install OCPDs level and plumb.

B. OCPDs in new distribution and branch circuit equipment shall be factory installed. OCPD's in existing distribution and branch circuit equipment shall match existing for type and be provided with features as listed herein.

C. Install fuses in fusible devices as indicated. Arrange fuses so that fuse ratings are readable without removing fuse.

D. All fuses for new disconnect switches or MCC's feeding motors or motor starters shall be provided with Class J fuses.

3.2 IDENTIFICATION:

A. Identify components in accordance with Division 26 Section on electrical identification.

3.3 CONTROL WIRING INSTALLATION:

A. Install wiring between OCPDs and control/indication devices.

3.4 CONNECTIONS:

A. Check connectors, terminals, bus joints, and mountings for tightness. Tighten field-connected connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and UL 486B.

3.5 GROUNDING:

A. Provide equipment grounding connections for individually mounted OCPD units as indicated and as required by NEC. Tighten connectors to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounding.

3.6 FIELD QUALITY CONTROL:

A. Reports: Prepare written reports on tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include complete records of repairs and adjustments made. Tests shall be made on all new and existing OCPD's provided and/or connected under this project in accordance with this section.

B. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.

C. Schedule visual and mechanical inspections and electrical tests with at least one week's advance notification.

D. Upon completing installation of the system, perform the following tests:

1. Visual and mechanical inspection: Include the following inspections and related work.

a. Overcurrent-Protective-Device Ratings and Settings: Verify indicated ratings and settings to be appropriate for final system arrangement and parameters.

b. Inspect for defects and physical damage, NRTL labeling, and nameplate compliance with current single line diagram.

c. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.

d. Check tightness of electrical connections of OCPD's with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.

e. Clean OCPD's using manufacturer's approved methods and materials.

f. Verify installation of proper fuse types and ratings in fusible OCPD's.

2. Electrical Tests: Perform the following tests in accordance with manufacturer's instructions:

a. Insulation resistance test of fused power circuit devices, insulated-case, and molded-case circuit breakers, 600-ampere frame size and over at 1000 degree V d.c. for one minute from pole to pole and from each pole to ground with breaker closed and across open contacts of each phase. Insulation resistance less than 100 megohms is not acceptable.

b. Make insulation resistance tests of OCPD buses, components, and connecting supply, feeder, and control circuits.

c. Make continuity tests of circuits.

d. Provide full rated primary current tests conforming to IETA testing standards of all new and existing breakers 800amperes and greater, connected under this project. Inspect breakers and provide test report. Set breakers to previous or new settings as directed prior to test.

e. Verify relay operation by introduction of accurately metered currents into overcurrent/ground fault/ and other circuitry at values which will enable accurate determination of the tripping or activation values.

E. Make adjustments for final settings of adjustable-trip devices.

F. Activate auxiliary protective devices such as ground fault or under-voltage relays, to verify operation of shunt-trip devices.

G. Check stored-energy charging motors for proper operation of motor, mechanism, and limit switches.

H. Check operation of electrically operated OCPDs in accordance with manufacturer's instructions.

I. Check key and other interlock and safety devices for operation and sequence. Make closing attempts on locked-open and opening attempts on locked-closed devices including moveable barriers and shutters.

J. Retest: Correct deficiencies identified by tests and observations and provide retesting of OCPDs by testing organization. Verify by the system tests that specified requirements are met.

3.7 DEMONSTRATION:

A. Training: Arrange and pay for the services of factory-authorized service representatives to demonstrate OCPD's and train Owner's maintenance personnel.

B. Conduct a minimum of one day of training in operation and maintenance as specified under in the Project Closeout Section of these specifications. Include both classroom training and hands-on equipment operation and maintenance procedures.

C. Schedule training with at least seven days' advance notification.

END OF SECTION 262800

SECTION 263213 - DIESEL GENERATOR SETS

PART 1 GENERAL

1.1 SUMMARY:

A. Extent of diesel generator set work is indicated by drawings and schedules, and is to include, but not limited by: diesel engine, electrical generator, engine starting system including batteries, instrument control panel, weather-protective housing, transfer switches, fuel tank, annunciator panel, exhaust silencer, and accessories.

B. System Description: Diesel engine-driven generator to provide source of essential emergency power.

C. Concrete and grout work for engine-driven generator pads, foundations, frames and bedplates are specified in Division-3 "Concrete" sections; not work of this section.

1.2 SUBMITTALS:

A. Product Data: Submit manufacturer's data on diesel engine- driven generator sets and components and include a copy of the manufacturer's standard product warranty.

B. For new construction document permit submittals (i.e. construction documents submitted to the Building Department for permit) the following minimum information shall be included to allow a deferred generator permit submittal:
1. Size of the fuel tank
2. Location of the generator showing clearances
3. Site plan for exterior generators showing clearances
4. Piping plan for fuel tank vents and remote fueling
5. Elevation view of the exterior building showing tank vent terminations, exhaust termination, exhaust and intake louvers and remote fuel fill with respect to building openings. Where it is not clear if openings are operable or not, they shall be labeled accordingly.
6. Electrical and mechanical information as required for Development Services permitting requirements.

C. Checklist: Submit a detailed checklist which acknowledges compliance or a reason for non-compliance to each of the specification requirements. Arrange the checklist according to the headings of each item identified in this specification (i.e. Shop Drawings, Wiring Diagrams individual line items, etc.) Mark items as "N/A" where the item is not applicable.

D. Wiring Diagrams: Submit wiring diagrams for diesel engine-driven generator unit showing connections to generator output breaker, control panels, transfer switches or breakers, alarms, remote alarms and ancillary equipment. Show and differentiate between portions of wiring that are manufacturer-installed and portions that are field-installed. The unit diagrams shall be for the particular unit to be supplied with all other information removed.

1. All interconnection and wiring diagrams shall include the following information as a minimum:

a. Complete diagrams of the internal wiring for each of the items of equipment.

b. The diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

E. Certifications:

1. Provide diesel engine-driven generator set's manufacturer certified test record of the final production testing prior to shipping the unit from the factory to the project site. Include the following tests:

a. Single-step load pickup.
b. Transient and steady-state governing.
c. Safety shutdown device testing.
d. Voltage regulation.
e. Rated power.
f. Maximum power.

F. Factory Testing: Submit a factory test log of diesel engine-alternator set showing a minimum of four (4) hours testing at 100 percent rated load to the Owner prior to shipment of the generator set. Load testing shall have a 0.8 power factor lagging continuously.

1. Normal preliminary diesel engine and generator tests shall be performed before unit assembly.
2. All engine safety features shall be tested for operation and calibrated prior to the load test.
3. All control and relay functions shall be tested for proper operation.
4. A high potential test of the alternator shall be performed.
5. All tests shall be conducted at 110°F. The actual radiators to be installed shall be used.
6. The following engine run data shall be recorded at 15 minute intervals:

a. Time
b. kW output
c. Output Voltage
d. Amperes
e. RPM
f. Input water temperature
g. Output water temperature
h. Input oil temperature
i. Fuel pressure
j. Oil pressure
k. Ambient temperature
l. Radiator inlet air temperature if different than ambient.

7. All test sheets will be submitted at the completion of the test. The vendor shall contact the Owner for scheduling and coordination of the factory test. Owner personnel or an Owner representative shall have the opportunity to witness the test.

G. Submit engine horsepower curves indicating manufacturer's approval of the engine rating for standby power application based on actual testing of a similar package. Special ratings or "maximum" ratings are not acceptable.

H. Provide information on the content and capacity of exhaust gases emitted by the engine at 1/4, 1/2, 3/4, and full load. The exhaust gas omission shall comply with all Federal, State and Local Codes in force at the site location.

I. Submit de-rating data, calculations, and final unit rating for the specified operating conditions at the site, where they differ from the vendor’s stated standard operating conditions.

J. Submit the generator harmonic analysis report for the 3rd, 5th and 7th harmonics that shows compliance with this specification.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of diesel engine-driven generator units and ancillary equipment, of types, ratings and characteristics required, whose products have been in satisfactory use in similar service for not less than 5 years.

1. The engine-generator shall be assembled, thoroughly tested and warranted, as the product of a single manufacturer. Sets which are assembled components by a service type facility are not acceptable.

2. The engine-generator set supplier shall be fully capable of providing all site service work on the engine-generator set and all accessories including:

a. Repair or replacement of any component including large assemblies such as generator rotors, drive shafts, etc.

b. Testing and trouble shooting.

c. General maintenance.

3. The engine generator set supplier shall have in local stock, all customary parts required for service of the unit including engine parts and electrical assemblies.

4. The engine generator set supplier shall maintain a service shop located within two/four hours drive from the job site and shall have fully equipped service trucks with mechanic/technicians available and on-call 24 hours per day.

B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with diesel engine-driven generator units similar to that required for this project.

1. Agreement to Maintain: The Installer must be willing to execute with the Owner, an agreement for continued maintenance of diesel engine-driven generator units.

1.4 DELIVERY, STORAGE AND HANDLING:

A. Deliver diesel engine-driven generators properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory-fabricated type containers or wrappings for engine-generator and components which protect equipment from damage.

B. Store diesel engine-driven generator equipment in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.

C. Handle diesel engine-driven generator equipment carefully to prevent physical damage to equipment and components. Do not install damaged equipment; remove from site and replace damaged equipment with new.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturers: Subject to compliance with requirements, provide diesel generator sets of one of the following:

1. MDF
2. Cummins/Onan Engine Co.
3. Caterpillar Tractor Co.
4. Kohler Corp

2.2 RATINGS:

A. The engine-generator set shall have the following minimum measured ratings when installed at the specified site and all derating factors including those for temperature, altitude, fan, charging generator, water pump, etc. are considered.

1. Duty : Essential Standby
2. Kilowatts: 150KW
3. Power Factor: 0.8
4. Frequency: 60 Hz Nominal
5. Voltage: 277Y/480V
6. Phase: 3
7. Wire: 4

2.3 ENVIRONMENTAL CONDITIONS:

A. The equipment specified is intended for application in an environment as described below:

1. Altitude: 5500 feet above sea level.
2. Maximum Temperature: 120 degrees F
3. Minimum Temperature: -20 degrees F
4. Location: Outdoor

2.4 ENGINE:

A. Type: direct fuel injected, liquid cooled with unit mounted radiator and engine driven water pump, multi-cylinder inline or v-type, two/four stroke cycle, compression ignition diesel, internal combustion engine. Diesel engine shall comply with the requirements of SAE 1349, ISO 8528 (Part 2), EGSA 101P and IEEE Standard 446 as they apply to standby application.

B. Fuel System: Appropriate for use of No. 2 fuel oil.

C. Governor: Isochronous type to maintain governed speed at rated frequency regardless of the kW load and shall meet the following requirements:

1. Stability: 0.25 percent maximum frequency variation at any constant load from no load to full load.

2. Regulation; 0.25 percent maximum frequency deviation at steady state. Provide a separate overspeed device, independent of the governor, to prevent runaway in the event of any failure which may render the governor inoperable.

D. Engine Accessories: Provide the following engine accessories.

1. Fuel filter.
2. Lube oil filter.
3. Intake air filter.
4. Lube oil cooler.
5. Fuel transfer pump.
6. Fuel priming pump.
7. Gear-driven water pump.

E. The engine shall be designed to develop rated speed and torque capable of developing full load within 8 seconds from the time the engine starts. Engine cranking period shall not exceed 30 seconds.

F. The lubrication system shall incorporate a threaded, spin-on or canister type, full flow, duplex filtration system with a spring loaded, pressure calibrated, bypass valve to allow lubrication to continue in the event of unusually high filter restriction. The bypass valve must be an integral part of the engine filters or filter housings. Locate filters for easy servicing. A local alarm shall be generated if bypass occurs.

1. A prelube oil system shall be used only when recommended by the manufacturer to reduce engine wear and improve starting time.

2. Provide engine with an initial fill (including oil makeup tank) of manufacturer's recommended multi-viscosity lubricating oil.

G. Provide a valved oil drain extended past the engine frame with braided stainless steel hose and reusable fittings.

H. Provide an automatic lube oil make-up system (REN or equivalent) to automatically maintain proper oil level in the engine crank case. Equip the system with a reserve oil supply tank sized for the engine provided, and based on the manufacturer's recommendation for oil consumption during a 72 hour engine run. Provide a shut-off valve between the tank and float valve and a

shut-off valve between the float valve and oil pan. All flexible hoses shall be of the braided stainless steel type.

I. The engine shall be equipped with protective devices to meet control requirements specified elsewhere in this specification. The control devices shall be tied into the engine generator control. All protective devices shall be wired into a master engine terminal box with terminal strips for remote connections and connections to annunciators or controls as required.

J. All equipment shall operate with minimum vibration throughout the operating range as assembled units. The equipment supplier shall assume all additional shop, shipping and transportation expense, and/or cost at the job site necessary to reduce excessive vibration attributable to unbalance of the equipment.

2.5 GENERATOR CHARACTERISTICS:

A. The generator shall be provided in accordance with the following:

1. The generator shall be of the single-bearing type, dripproof construction, externally regulated, directly connected to the engine flywheel through a semi-flexible coupling. The generator shall be complete with inboard brushless exciter. The generator rotor shall be dynamically balanced to withstand overspeeds up to 125 percent rated speed.

2. The generator shall comply with NEMA Standard MG-1, latest revision. Insulation shall be Class F. Rotor and stator temperature rise shall not exceed 105 degrees C. over a 40 degree C. ambient temperature at specified site altitude. Generator must be derated in accordance with NEMA MG-1.

3. Provide a minimum generator subtransient reactance of 23%.

4. The generator shall be capable of continuously delivering its rated output at any power factor from 1.0 to 0.8 lagging at ±5 percent of rated voltage and at 60Hz, in the environmental conditions as specified.

5. Insulation shall be 100 percent epoxy material, pressure impregnated.

6. Stator winding pitch shall be optimized for best wave shape.

7. The generator voltage regulator shall be solid state, with external voltage adjust rheostat. Provide a setscrew stability adjustment. Voltage regulation shall be +1.0 percent. Steady state voltage stability shall remain within a 0.5 percent band of rated voltage.

8. The engine alternator shall be capable of accepting a one-step application of 100% of nameplate kW load at 0.8 power factor and recover to steady state conditions without disruption of power to the load. When the alternator is sequentially loaded with rated full load in three equal steps, the transient voltage drop at any step shall be limited such that the alternator voltage is not less than 75% of nominal voltage, and frequency is not less than 91% of nominal. In addition, the voltage at the alternator shall recover to within 90% of nominal voltage and the frequency to within 97% of nominal within 4

seconds after each sequential load application, or 60% of each step time interval (whichever is less).

9. During recovery from transients caused by step-load increases, step-load decreases, or resulting from 100% load rejection, the speed of the diesel alternator set shall not reach the over speed shutdown setpoint.

10. The generator shall be capable of providing 300 percent of rated current for ten seconds during a short circuit condition.

11. The generator shall be of four/ten/twelve lead design connected in three phase, 4 wire/wye single phase, 3 wire/wye configuration. Neutral capacity shall be 100 percent of each phase.

12. Telephone influence factor (TIF) shall not exceed 50.

13. Generator bearing shall be designed for a minimum B-10 bearing life of 40,000 hours. The bearing shall be of the shielded type with provisions for lubricating without opening terminal compartment.

14. For multiple engine/generator applications, coordinate generator pitch/impedance, and other factors of each new and existing system for proper paralleling characteristics.

15. All generator leads (including neutral) shall be extended un-spliced from windings to generator connection junction box external to generator.

2.6 STARTING EQUIPMENT:

A. General: The engine shall be equipped with a 12/24 volt electric starting system of sufficient capacity to crank the engine at a speed which will allow starting of the engine.

1. Starting system shall be capable of starting the engine either manually or automatically.

B. Batteries:

1. The batteries shall be dedicated to the engine.

2. Provide maintenance free lead acid batteries having sufficient capacity for cranking the engine for at least 40 seconds at firing speed in the minimum ambient temperature specified.

3. The battery positive and negative terminals shall be of threaded type. The positive terminal shall be identified by a red plastic disc at the base.

4. Rigid connections shall be manufactured of nickel plated high quality copper bar. Flexible intercell connections shall be made out of copper cable with appropriate insulation. Nickel plated lead, or nickel plated steel are not acceptable for flexible or rigid connections. The battery cables shall be welding type cable using compression connectors and shall have physical protection. Provide corrosion inhibiting compound on all cable terminations.

C. Accessories:

1. Provide a battery rack and necessary cables and clamps. Battery rack shall be designed and secured to match the specified seismic zone.

2. A suitable battery charging alternator shall be provided with sufficient capacity to recharge the batteries back to normal starting requirements within 90 minutes.

3. Provide battery blanket for 120 volt a.c. supply.

4. Provide continuous clear non-conductive covers for each row of terminals in rack.

D. Battery Charger:

1. Provide a battery charger specifically designed for engine starting batteries which shall maintain the starting batteries at full charge. The charger shall be capable of restoring the batteries to a fully-charged state within eight hours after a complete duty cycle discharge.

2. The charging system shall permit charging from either a normal or emergency 120 volt AC power source.

3. The charger shall be so designed that it will not be damaged during the engine cranking.

4. The charger shall be equipped with the following accessories, as a minimum:

a. Ammeter
b. Voltmeter
c. Fused AC input and fused DC output

2.7 COOLING SYSTEM:

A. Provide the engine with a liquid cooled unit mounted radiator. Radiator fan shall be of the pusher type. Radiator shall be rated for the specified ambient temperature and shall be of the de-aeration type.

1. Provide each engine with a dedicated system of radiator, pumps, piping controls and alarms.

2. Provide a radiator auxiliary pump (if required) with starter.

3. Provide radiator fan, motor and starter. The fan shall be direct drive and have guards to OSHA Standards.

4. Where the radiator is located above the engine, provide heat exchanger if the hydraulic head will be greater than the manufacturer’s recommendation for the engine.

a. Provide heat exchanger capacity 15 percent greater than the engine heat rejection.

5. Noise level shall be a maximum of 75 db at 23 feet. (7m.).

B. All coolant system hoses shall be braided stainless steel. Hoses shall be rated for the maximum pressure that can be experienced under normal conditions, with system blockages, and shall not collapse under the most severe suction conditions. Coolant hoses shall not be painted. Provide a coolant recovery system that will prevent coolant overflow and spillage. The system shall have a capacity of 20 percent of the total coolant capacity of the unit.

C. Provide spin-on type water filters with anti-scale agent.

D. The engine cooling system shall be filled with anti-freeze with a minimum of 50 percent ethylene glycol antifreeze in water. Provide glycol for complete piping and radiator system.

E. Provide a valved radiator drain with pipe extension and threaded connection at a location easily accessible to maintenance personnel.

F. Provide OSHA guards on all belts, pulleys and fans.

G. Provide necessary pipe fittings. Provide necessary valves for ease of access and maintenance.

H. Provide minimum of two belts to radiator fan drive

2.8 AIR INTAKE SYSTEM AND EXHAUST SYSTEM:

A. Provide a dry type air intake filter and silencer. Mount on the engine in an accessible location.

B. Provide a stainless steel, corrugated, flexible exhaust pipe in between the engine exhaust flange and silencer to prevent the transmission of vibration. Minimum length shall be 18 inches.

C. Provide a critical type exhaust silencer. The silencer shall be compact type.(For confined indoor spaces.)

1. Provide exhaust silencer mounting bands and brackets.

D. Provide a closed crankcase ventilation (CCV) filtration system mounted with the engine per manufacturer's instructions. Provide piping from the engine to the CCV unit, from the CCV unit to the silencer and from the CCV unit drain back to the engine, sized and installed per manufacturer's instructions.

1. Where ambient temperature around the engine may allow the CCV unit to get below freezing temperature, provide a CCV heater kit. Heater kits are only required for severe conditions. Consult the generator manufacturer to determine if the heater will be necessary.

E. Provide flanges, non-slip type connectors and gaskets. Exhaust lines shall be gas tight. Connections are to be welded and/or flange type.

2.9 FUEL SYSTEM:

A. Provide a double walled sub base mounted fuel tank and fuel system designed for #2 fuel oil.

B. Tank shall meet the following requirements:

NFPA 30 and 30A

Colorado Department of Labor and Employment-Division of Oil and Public Safety Storage Tank Regulations 7 C.C.R.1101-14

UL142 requirements for Above Ground Double Wall Steel Storage Tanks

C. Provide fuel tank with sufficient capacity to operate the system at 100 percent kW load for 24 hours continuously.

D. Provide necessary pumps, floats, piping and connections including connections to external fuel fill via a drop tube. Plumbing and wiring shall be pre-connected and supplied integral with the generator package.

E. Provide full fuel tank at the end of this project. Fuel tanks shall have initial fill for testing and be refilled when testing is complete with specified diesel fuel.

F. Provide the following accessories:

1. Two 3 inch fuel ports in tank for fuel stirring. Each port shall have gas cap. Locate ports at remote and opposite ends of tank.
2. Calibrated fuel level stick.
3. Tank drain
4. Provide interstitial monitoring and alarm to detect a fuel leak between tank walls.

G. An application for tanks larger than 660 gallons must be submitted to and approved by the Director of the Colorado Division of Oil and Public Safety, before beginning construction on any new petroleum AST system at a particular facility; or before beginning construction on any existing petroleum AST system at a facility that is being upgraded to the standards 7 C.C.R 1101-14.

H. Submit a visual inspection record of the tank at the conclusion of the project as required by 7 C.C.R.1101-14.

2.10 STARTING AIDS:

A. Provide 208 volt AC single phase engine jacket water heaters installed on the engine. The heaters shall be sized to provide an engine jacket temperature of 90 degrees F. in the minimum ambient temperature specified.

2.11 MOUNTING:

A. Provide a suitable full length sub-base for mounting the engine generator unit on a concrete foundation.

B. Provide vibration isolation between engine-generator and sub-base fuel tank. Fuel tank shall be bolted to floor.

C. Mounting shall be designed, constructed, and installed to meet applicable seismic zone requirements.

2.12 ENGINE GENERATOR CONTROL PANEL:

A. Provide an automatic starting control panel, powered via engine start batteries.

1. The control panel shall be installed on the generator facing the rear of the unit.

B. The engine generator control panel shall be equipped with the following items:

1. Provide the following analog/digital meters with 2% accuracy, minimum size 2-1/2"/4-1/2 “:

   a. Generator ammeter
   b. Generator voltmeter
   c. Generator frequency meter
   d. Generator kilowatt meter
2. Manual/Off/Reset/Automatic selector switch.
3. Ammeter-Voltmeter phase selector switch.
4. Voltage level adjustment rheostat.
5. Accessory output contact which closes when the generator starts, for interlocking with remote items.
6. Fuel level status.
7. CT test block with shorting CT contacts and insertion tool, mounted on the front of the control panel.
8. Lube oil pressure gauge.
9. Alarm silence.
10. Parallel relays from each pre-alarm and alarm condition with dry contacts wired to alarm terminal strip.
11. Elapsed time meter.
12. Alarm lamp test pushbutton.

C. Control Start Sequence: Upon a remote contact closure, the auto-start panel shall automatically provide up to four cranking periods of ten seconds each with up to three rest periods of ten seconds in between. Should the engine fail to start, an over-crank timer shall lock out the engine from further attempts, sound an alarm, and provide an output contact closer for a remote alarm.

D. Provide a local and remote alarm annunciator with audible and visual indications as listed below and to comply with NFPA 110 Level 1.

1. Provide with test/cancel pushbuttons, audible alarm silencing switch, contacts for local and remote alarms.

2. Locate the alarm panel in the engine generator control panel.

3. The annunciator shall alarm the following conditions:

4. Provide the following additional alarm outputs with Form C contacts (normally closed, open on alarm).

   a. Standby engine run
   b. Standby engine failure (To originate from the alarm annunciator)
   c. Standby engine start system failure (To originate from the alarm annunciator)
   d. Low fuel main tank
   e. Low fuel day tank

E. Provide auxiliary engine run contacts for control of auxiliary systems required for operation of engine, such as ventilation, fuel system, electric start, regulator, governor, remote mounted fan, etc. Provide normally closed contacts for operation of intake and exhaust air dampers. In addition, provide a minimum of four (4) spare SPDT contacts.

2.13 GENERATOR CIRCUIT BREAKER:

A. Provide output main line circuit breaker which shall operate both manually as an isolation switch and automatically during overload and short circuit conditions.

B. The trip unit for each pole shall have elements providing inverse time delay during overload conditions and instantaneous magnetic tripping for short circuit protection. The circuit breaker shall meet standards established by UL, NEMA and the NEC.

C. Provide generator circuit breaker in a NEMA 1 enclosure adjacent to the generator terminal compartment. Provide sufficient space for conduit and cable termination in and around the circuit breaker enclosure.

D. Provide circuit breaker with auxiliary contacts which provide contact closure upon breaker automatic trip or manual opening. The alarm contact is to be used for remote annunciation of circuit breaker tripped or open.

2.14 STATE OF ASSEMBLY:

A. The engine generator system shall be factory assembled. Clean and paint all components per manufacturer's standards.

B. Accessory items shall be mounted directly on engine generator skid except where freestanding or remotely mounted. Provide all wiring and conduit fully installed and include termination points for remote or freestanding items.

   1. Connections between generator and remote or freestanding items are excluded from this specification.

2.15 EXTRA MATERIALS:

A. Provide spare parts for one year's maintenance of the engine generator system. Parts shall be labeled with the equipment identification which they are associated with and packed for storage. Spare parts shall include but not be limited to:

1. Belts: Provide 2 of each type.
2. Hoses: Provide 2 of each type.
3. Fuses for voltage regulator and controls: Provide 3 of each type.
4. Filters: Provide 2 of each type, (fuel, air, water, oil, etc.)
   Lamps: Provide 2 of each type.

2.16 SOUND ATTENUATING WEATHERPROOF HOUSING:

A. General: Provide a complete and operational generator enclosure, including all devices and equipment specified herein, as shown on the drawings and as required for service. Enclosure shall be new and delivered ready for installation.

B. The enclosure shall conform with local building codes for the specified location and to withstand the highest level of winds as listed by the ANSI Basic Wind Speed Map for the contiguous United States.

C. Skin-Tight/Reach-In:

1. Enclosure shall be skin tight/reach-in type and factory standard option. Submit proposed factory detail drawings that fully identify enclosure construction, clearances, and access. Enclosure shall be constructed of all welded, formed sheet steel or bolted with sealed seams. Construction shall allow for ability of panel replacement as well as engine/generator repairs to be performed without complete enclosure removal.

2. Provide louvers sized to properly cool the generator set at site conditions as specified. Louvers shall be fixed/gravity/motor operated discharge and fixed/motor operated intake.

3. Provide sound attenuation on all four sides and top of enclosure to 65/75 (75 typical, 65 is custom) dbA at 25 feet per local code requirements.

4. Enclosure Accessories:

a. Provide exhaust silencer mounting bands and brackets for internal/external silencer.

b. Provide floor mounted battery racks.

c. Provide wall mounted battery charger.

d. Extend coolant and oil drains to outside of enclosure.

e. Extend fuel tank vents through roof of enclosure.

PART 3 EXECUTION:

3.1 EXAMINATION:

A. Examine areas and conditions under which diesel engine-driven generator units are to be installed and notify the Engineer in writing of conditions detrimental to proper completion of

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

3.2 INSTALLATION OF DIESEL ENGINE-DRIVEN GENERATOR SETS:

A. Install diesel engine-driven generator units in accordance with the equipment manufacturer's written instructions, and with recognized industry practices, to ensure that engine-generator units fulfill requirements. Comply with NFPA and NEMA standards pertaining to installation of engine-generator sets and accessories.

B. Coordinate with other work, including raceways, electrical boxes and fittings, fuel tanks, piping and accessories, as necessary to interface installation of engine-generator equipment work with other work.

C. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Stds 486A, B and the National Electrical Code.

D. Install units on vibration isolators in accordance with manufacturer's indicated method of installation.

E. Connect fuel oil piping to generator equipment as indicated, and comply with manufacturer's installation instructions.

3.3 GROUNDING:

A. Provide equipment grounding connections for diesel engine- driven generator units as indicated. Tighten connections to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounding.

3.4 FIELD QUALITY CONTROL:

A. Start-up Testing: Engage local equipment manufacturer's representative to perform start-up and load tests upon completion of installation, with the Engineer in attendance; provide certified test record.

B. The Contractor shall provide qualified personnel, load bank, cables, test equipment and all other necessary materials required and perform the following tests:

1. Check fuel, lubricating oil, and antifreeze in liquid cooled models for conformity to the manufacturer's recommendations under environmental conditions present.

2. Test accessories that normally function while the set is in a standby mode for proper operation, prior to cranking engine. Accessories include but are not limited to: engine heaters, battery charger, generator strip heater, remote annunciator, etc.

3. Check for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during running, normal and emergency line-to-line voltage and phase rotation during start-up test mode.

4. Test automatic start-up by remote-automatic starting, transfer of load, and automatic shutdown, by simulating a power outage. Prior to auto-start test, adjust transfer switch timers for proper system coordination. Monitor engine temperature, oil pressure, battery charge level, generator voltage, amperes, and frequency throughout the test, in accordance with NFPA 110 requirements/AT&T Standard Practice Checklist.

5. Test the complete system using a combination reactive/resistive load bank to 0.8 P.F.:

   a. 2 hours at 50 percent rated load
   b. 2 hours at 100 percent rated load (NFPA)

6. During load bank tests, record the following data on 15 minute intervals:

   a. Generator kW
   b. Generator amps on each phase
   c. Generator volts on each phase and phase to neutral
   d. Generator frequency
   e. Jacket input water temperature
   f. Jacket output water temperature
   g. Lube oil pressure
   h. Lube oil temperature
   i. Fuel pressure
   j. Exhaust back-pressure
   k. Ambient temperature
   l. Radiator inlet air temperature
   m. Oil, coolant or fuel leakage
   n. Generator stator temperature
   o. Battery charge rate (at 5 minute intervals for first 15 minutes then 15 minute intervals thereafter.

7. Provide additional data for the following:

   a. Time to recover stable rated frequency and voltage after step addition of 50 percent, 75 percent AND 100 percent rated load.

   b. Voltage dip when applying the above step loads.

C. Upon completion of installation, demonstrate capability and compliance of system with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting. Initial testing and retesting to be at no cost to Owner.

3.5 ADJUSTING:

A. Adjust battery charger output.

B. Adjust generator output voltage and engine speed.

3.6 CLEANING:

A. Clean engine and generator surfaces. Replace oil and fuel filters.

3.7 DEMONSTRATIONS:

A. Generator supplier shall provide Owner with a minimum of (4) hours field training and instruction.

B. Describe system operation under emergency conditions and restrictions for future load additions.

C. Simulate power outage by interrupting normal source, and demonstrate that system operates to provide emergency power.

3.8 OPERATION AND MAINTENANCE:

A. Documentation:

1. Upon completion of the project, provide two complete operational and maintenance manuals to the owner. The manuals shall contain the following information:

a. Emergency instructions including addresses and telephone numbers for service sources.

b. Troubleshooting guidelines.

c. Complete operating instructions. All operating instructions shall include the following information as a minimum:

1) Manufacturer's operating instructions for each piece of equipment furnished.

2) Specific operating instructions for each portion of the system which involves multiple items of equipment.

3) Instructions for charging, start-up, control or sequencing of operation, phase or seasonal variations, shut-down, safety and similar operations.

d. Recommended maintenance procedures and intervals for all equipment.

e. Complete shop drawings related to the entire system.

f. Technical data sheets for all equipment.

g. Complete interconnection diagrams which indicate all components of the system, including control systems and alarm interface.

h. Manufacturer's maintenance data including complete parts lists, partial detailed parts drawings, etc. for each operational item in each system.

i. Ordering information for spare parts.

j. Manufacturer's product warranties and guarantee relating to the system and equipment items in the system.

B. Each maintenance manual shall be bound in vinyl-covered, 3-ring binders, with pocket-folders for folded drawings. The manual shall have an index with tabs for each section.

C. Provide the following additional operating documents:

1. A safety shutdown list provided on the generator set and in the generator maintenance manual. Verify that the appropriate safety controls have been provided based on the shutdown list.

2. Satisfactory engine/alternator test records, lubrication, fuel and start battery maintenance records with space for continued entries.

3. "Engine operating instructions" posted near the unit that provides clearly defined, step-by-step procedures for starting, running and stopping the engine.

4. Lockout-tagout procedures in place for the AC switchgear and distribution during normal operation, manual operation and testing.

3.9 WARRANTY:

A. Provide manufacturer's warranty for a duration of not less than two (2) years from the date of substantial completion of the project. The warranty shall include, but not be limited to, the replacement of materials and equipment used in diesel generator systems.

B. Extended Warranty Agreement: Offer terms and conditions for furnishing parts and providing continued testing and servicing, beyond the warranty period, including replacement of materials and equipment, for a one-year period with an option for renewal of the Agreement by the Owner.

C. Maintenance Agreement: Prior to time of final acceptance, the supplier shall submit 4 copies of an agreement for continued service and maintenance of the diesel engine-driven generator sets, for the Owner's review and possible acceptance.

END OF SECTION 263213

SECTION 263600 - TRANSFER SWITCHES

PART 1 GENERAL

1.1 SUMMARY:

A. This Section includes transfer switches rated 600 V and less. It includes the following items:

1. Automatic transfer switch with by-pass isolation (ATS).

1.2 SUBMITTALS:

A. Product data and shop drawings for each transfer switch, including dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and materials lists.

B. Checklist: Submit a detailed checklist which acknowledges compliance or a reason for non-compliance to each of the specification requirements. Arrange the checklist according to the headings of each item identified in this specification (i.e. shop drawings, wiring diagrams individual line items, etc). Mark items as “N/A” where the item is not applicable.

C. Wiring diagrams, elementary or schematic, differentiating between manufacturer-installed and field-installed wiring.

D. Single-line diagrams of transfer switch units showing connections between automatic transfer switch, bypass/isolation switch, power source, and load, plus interlocking provisions.

E. Operation and maintenance data for each type of product. Include all features and operating sequences, both automatic and manual. List all factory settings of relays and provide relay setting and calibration instructions.

F. Manufacturer's certificate of compliance to the referenced standards and tested short-circuit closing and withstand ratings applicable to the protective devices and current ratings used.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of electrical power transfer switches, of types, ratings, and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects utilizing electrical power transfer switches similar to that required for this project.

C. Emergency Service: Manufacturer with a service center capable of providing emergency maintenance and repairs at the Project site with an 8-hour maximum response time.

D. Comply with NFPA 99, "Standard for Essential Electrical Systems for Health Care Facilities," and NFPA 110, "Standard for Emergency and Standby Power Systems."

E. Comply with NEMA Standard ICS-2-447-AC Automatic Transfer Switches.

F. UL Listing and Labeling: Items furnished under this Section shall be listed and labeled by UL for Emergency Service under UL Standard 1008.

G. National Recognized Testing Laboratory Listing (NRTL) and Labeling: Items furnished under this Section shall be listed and labeled by a NRTL for emergency service under UL Standard 1008.

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

2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

H. Single-Source Responsibility: Obtain ATSs, BP/ISs, remote annunciators, and remote annunciator and control panels from a single manufacturer that assumes responsibility for all system components furnished.

I. Source Quality Control: Factory test components, assembled switches, and associated equipment to ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for conformance with specified requirements. Perform dielectric strength test conforming to NEMA ICS 1.

1.4 DELIVERY, STORAGE AND HANDLING:

A. Deliver transfer switches and associated devices in factory-fabricated type containers or wrappings, which properly protect equipment from damage.

B. Store transfer switches and associated devices in original packaging, and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.

C. Handle transfer switches and associated devices carefully to prevent physical damage to equipment. Do not install damaged equipment; remove from site and replace damaged equipment with new equipment.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

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

1. GE Zenith Controls, Inc.
2. Automatic Switch Company. (ASCO)
3. Russelectric, Inc.
4. Same manufacturer as generator

2.2 TRANSFER SWITCH PRODUCTS, GENERAL:

A. Number of Poles and Current and Voltage Ratings: As indicated on one line diagram.

B. Tested Fault-Current Ratings: Closing and withstand ratings shall exceed the indicated available rms symmetrical fault current at the equipment terminals based on testing according to UL Standard 1008, conducted at full-rated system voltage and 20 percent power factor. For closed transition transfer switch, the fault current rating shall exceed that of the combined utility and generator in parallel. Rate each product for withstand duration time as follows when tested for rated short-circuit current correlated with the actual type of circuit protective device indicated for transfer switches for this Project.

1. 1.5 closing and withstand duration cycles.

C. Annunciation and Control Interface Components: Provide devices at transfer switches for communicating with remote annunciators or annunciator/control panels which have communications capability matched with the remote device.

D. Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 degrees C. to 70 degrees C.

E. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage surge withstand capability requirements when tested according to ANSI C37.90.1, IEEE Guide for Surge Withstand Capability (SWC) Tests. Components meet or exceed voltage impulse withstand test of NEMA ICS 1.

F. Neutral Terminal: Where 2- or 3-pole switches are indicated, provide fully rated, solid, unswitched neutral terminal.

G. Enclosures: Provide a general-purpose NEMA 1 enclosure, conforming to UL Standard 508, "Electrical Industrial Control Equipment," except as otherwise indicated.

H. Factory Wiring: Train and bundle factory wiring and identify consistently with shop drawings, either by color code or by numbered or lettered wire and cable tape markers at terminations.

1. Designated terminals accommodate field wiring.
2. Power Terminal Arrangement and Field Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Terminals: Pressure-type, suitable for copper or aluminum conductors of sizes indicated.
4. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

I. Electrical Operation: Where indicated, accomplish by a non-fused, momentarily energized solenoid or electric motor-operated mechanism, mechanically and electrically interlocked in both directions. Switches using components of molded-case circuit breakers or contactors not designed for continuous-duty, repetitive switching between active power sources is not acceptable.

J. Switch Action: The switch contacts shall be mechanically held in both directions for double-throw switches.

K. Switch Contacts: Use silver composition for switching load current. Units rated 225 amperes and more shall have separate arcing contacts.

L. Overcurrent devices are not part of switch products.

M. Transfer switch shall use copper bus throughout.

N. Control power for transfer switches shall operate from either source as available and shall include a connection terminal for a third separate source of power. Control, indication alarms, etc. shall operate from any of these sources automatically.

O. Provide two-hole compression lugs on all incoming and load side phase, neutral, and ground connectors.

2.3 AUTOMATIC TRANSFER SWITCHES (ATSS):

A. Comply with Level 1 equipment according to NFPA 110, "Standard for Emergency and Standby Power Systems."

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning [except for neutral position, to enable programmed transition.]

C. Manual Switch Operation: The switch shall have provision for manual operation under load with the door closed with either or both sources energized. Transfer time shall be the same as for electrical operation. Control circuit shall automatically disconnect from electrical operator during manual operation.

D. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts shall operate in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.

E. Digital Communications Interface: Provide full-duplex RS - 485/422/232 type, matched to capability of remote annunciator and control panel.

F. In-Phase Monitor: Include factory-installed and factory-wired internal in-phase monitor relay. The relay controls transfer so it occurs when the 2 sources are synchronized in phase. the relay compares phase relationship and frequency difference between the normal and emergency sources and initiates transfer when both sources are within +5 electrical degrees and +5 percent voltage difference, and then only if the transfer can be of nominal frequency and 70 percent or more of nominal voltage.

2.4 AUTOMATIC TRANSFER SWITCH FEATURES:

A. Provide for normal source voltage sensing of each phase of normal source. Pick-up voltage shall be adjustable from 85 percent to 100 percent nominal, and drop-out voltage is adjustable from 75 percent to 98 percent pick-up value. Factory set for pick-up at 95 percent and drop-out at 85 percent.

B. Provide for emergency source voltage sensing to prevent premature transfer. Voltage pick-up shall be adjustable from 85 percent to 100 percent of nominal. Factory set to pick-up at 90 percent. Pick-up frequency shall be adjustable from 90 percent to 100 percent of nominal and factory set to pick-up at 98 percent.

C. Provide a transfer switch signal time delay to override normal source voltage-sensing, delay transfer signal and engine start signal. Delay shall be adjustable from 0 to 6 seconds, and factory set at 5 sec.

D. Provide a transfer to emergency time delay to delay transfer switch changeover after transfer signal. Delay shall be adjustable from 0 to 5 minutes and factory set at 0 minutes.

E. Provide a retransfer time delay to provide for automatic defeat of the delay upon loss of voltage or sustained undervoltage of the emergency source, provided the normal supply has been restored. Delay shall be adjustable from 0 to 30 minutes and factory set at 15 minutes.

F. Provide an engine shut-down time delay adjustable from 0 to 15 minutes and factory set at 5 minutes.

G. Provide a momentary type test switch to simulate normal source failure.

H. Provide switch position pilot lights to indicate source to which the load is connected.

I. Provide source available indicating lights to supervise sources via the transfer switch normal and emergency source-sensing circuits.

1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."

2. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

J. Provide a transfer override switch to override automatic retransfer control so the ATS will remain connected to the emergency power source regardless of the condition of the normal source. Provide a pilot light to indicate the override status.

K. Provide engine starting contacts, one isolated normally closed and one isolated normally open. Contacts shall be gold flashed or gold plated and rated 10 amperes at 32 V d.c. minimum.

L. Provide an elevator pre-signal relay to signal the elevator equipment that re-transfer to normal source is imminent and to shutdown SCR controller, then startup after re-transfer.

M. Exerciser transfer selector switch which permits selection between exercise with and without load transfer.

1. Push button programming controls with digital display of settings.
2. Integral battery operation of time switch when normal control power is not available.

N. Description: By Pass Isolation Manual type, arranged to select and connect either source of power directly to the load, isolating the transfer switch from the load and from both power sources. Include the following features:

1. Means to lock the BP/IS in the position that isolates the transfer switch, with an arrangement that permits complete electrical testing of the transfer switch while isolated. While isolated, interlocks shall prevent transfer switch operation except for testing or maintenance.

2. Draw-out arrangement for the transfer switch: Provide physical separation from live parts for testing and maintenance operations.

3. Current, voltage, closing, and short-circuit withstand rating shall be equal to or greater, than that of the associated ATS, with the same phase arrangement and number of poles.

4. Contact temperatures of BP/IS shall not exceed those of ATS contacts when they are carrying rated load.

5. Construct so that load bypass and transfer switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.

6. Provide a Manufacturer's standard legend for control labels and instruction signs which give detailed operating instructions.

7. Fabricate BP/IS to allow convenient removal of major components from the front without removal of other parts or main power conductors.

O. Interconnect BP/IS and ATS with copper bus bars plated at connection points and braced for the indicated available short circuit current.

PART 3 EXECUTION

2.5 EXAMINATION:

A. Examine areas and conditions under which transfer switches are to be installed and notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.

2.6 INSTALLATION OF AUTOMATIC TRANSFER SWITCHES:

A. Install transfer switches, including associated control devices as indicated, in accordance with equipment manufacturer's written instructions, and with recognized industry practices, to ensure that transfer switches comply with requirements. Comply with applicable requirements of NEC and NFPA pertaining to wiring practices and installation of electrical power transfer switches.

B. Coordinate with other electrical work, including raceways, and electrical boxes and fittings, as necessary to interface installation of transfer switch work with other work.

C. Tighten factory-made connections, including connectors, terminals, bus joints, mountings, and grounding. Tighten field-connected connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque tightening values. When manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and 486B.

2.7 GROUNDING:

A. Make equipment grounding connections for transfer switch units as indicated and as required by the NEC.

2.8 FIELD QUALITY CONTROL:

A. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise field tests.

B. Preliminary Tests: Perform electrical tests as recommended by the manufacturer and as follows:

1. Measure phase-to-phase and phase-to-ground insulation resistance levels with insulation resistance tester, including external annunciator and control circuits. Use test voltages and procedure recommended by the manufacturer. Meet manufacturer's specified minimum resistance.

2. Check for electrical continuity of circuits and for short circuits.

C. Field Tests: Give 7-day advance notice of the tests and perform tests in presence of Owner's representative.

D. Coordinate tests with tests of generator plant and run them concurrently.

E. Tests: As recommended by the manufacturer and as follows:

1. Contact Resistance Test: Measure resistance of power contacts for ATSs. Resolve values in excess of 500 micro-ohms and differences between adjacent poles exceeding 50 percent.

2. Ground Fault Tests: Coordinate with testing specified in Division 16 Section on Overcurrent Protective Devices to ensure sensors are properly selected and located to optimize ground-fault protection where power is being delivered from either source.

    a. Verify grounding points and sensor ratings and locations.

    b. Apply simulated fault current at the sensors and observe reaction of circuit interrupting devices.

3. Operational Tests: Demonstrate interlock, sequence, and operational function for each switch at least 3 times.

    a. Simulate power failures of normal source to ATSs and of emergency source with normal source available.
    b. Simulate low phase-to-ground voltage for each phase of normal source of ATSs.
    c. Verify time-delay settings and pick-up and drop-out voltages.
    d. Verify all control and relay devices operate properly in each sequence.

4. Test Failures: Correct deficiencies identified by tests and prepare for retest. Verify that equipment meets the specified requirements.

5. Reports: Maintain a written record of observations and tests. Report defective materials and workmanship and retest corrected items. Record adjustable relay settings and measure insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

2.9 DEMONSTRATION:

A. Training: Furnish the services of a factory-authorized service representative to instruct Owner's personnel in the operation, maintenance, and adjustment of transfer switches and related equipment. Provide a minimum of 4 hours of instruction scheduled 7 days in advance.

B. Post step-by-step procedures for each switch provided.

END OF SECTION 263600

SECTION 264313 - SURGE PROTECTIVE DEVICE (SPD)

PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of SPD work is indicated by drawings and by requirements of this section.

B. Types of SPD equipment required for this project include the following:

1. Type 2 for distribution panelboards.

1.2 QUALITY ASSURANCE:

A. Manufacturers: firms regularly engaged in manufacture of SPD equipment of types, ratings, capacities and characteristics required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's qualifications: firm with at least 5 years of successful installation experience with projects utilizing rectifier and invertor work similar to that required for this project.

C. The specified system shall be factory-tested before shipment. Testing of each system shall include but shall not be limited to quality control checks, "hi-pot" tests at twice rated voltage plus 1000 volts per UL requirements, IEEE c62.41 category b surge tests, UL ground leakage test, and operation and calibration tests.

D. The project shall be life cycle tested following suggested wait times as defined by ANSI/IEEE C62.45 (1987) and shall be capable of surviving 1000 sequential category C surges of 10,000 amps without failure.

E. The system shall be UL listed as a complete system under UL 1449 (rev 7/2/87) standard for surge protective device (SPD) and the rating shall be permanently affixed to the SPD.

1.3 SUBMITTALS:

A. Product data: Submit manufacturer's data on SPD equipment.

B. Shop drawings: Submit drawings of SPD equipment indicating unit dimensions, weights, component and connection locations, mounting provisions, connection details and wiring diagrams.

C. Operation and maintenance manual: The manufacturer shall provide an operation and maintenance manual containing installation, start-up, and operating instructions and a list of recommended spare parts for each system specified.

D. Test reports: Documentation of specified system's UL 1449 listing and clamping voltage ratings shall be provided. This shall include computer generated graphs and oscillograms. Tests shall follow procedures outlined in ANSI/IEEE C62.45 (1987) for installation category and applicable protection modes of SPD.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver SPD equipment and accessories individually packaged in factory-fabricated containers. Mount units on shipping skids.

B. Handle equipment carefully to prevent internal component damage, impact, breakage, denting, and scoring enclosure finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer.

C. Store equipment in clean dry space. Protect units from dirt, fumes, water, construction debris and traffic.

1.5 WARRANTY:

A. The manufacturer shall provide a full five year warranty from date of shipment against any part failure when installed in compliance with manufacturer's written instructions, UL listing requirements, and any applicable national or local electrical codes.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Manufacturer: subject to compliance with requirements, provide SPD products of the following:

1. GE/Liebert
2. Panelboard manufacturer

2.2 SYSTEM DESCRIPTION:

A. Environmental Requirements:

1. Relative Humidity: Operation shall be reliable in an environment with 5 percent to 95 percent non-condensing relative humidity.
2. Audible Noise: The audible noise level of the specified system shall be less than 45 dBA at 5 feet.
3. Operating Altitude: The system shall be capable of operating up to an altitude of 12,000 feet above sea level.
4. Magnetic Fields: Unit shall not generate appreciable magnetic field, and shall be capable of use directly in computer rooms in any location without danger to data storage systems or devices.

B. Electrical Requirements:

1. System Operation Voltage: The nominal system operating voltage shall be as indicated on drawings.
2. Maximum Continuous Operating Voltage (MCOV): The SPD maximum continuous operating voltage shall not be less than 115 percent of the nominal system operating voltage to ensure the ability of the system to withstand temporary RMS overvoltage conditions. Each system shall be factory tested at the MCOV for at least one (1) hour.
3. Operating Frequency: The operating frequency range of the system shall be at least 47 to 63 Hertz.

4. Protection Modes: The SPD shall provide protection as follows:

   a. Line to line
   b. Line to ground
   c. Neutral to ground
   d. Line to neutral

2.3 SPD EQUIPMENT:

A. Components: The system shall be a symmetrically balanced, metal oxide varistor (MOV) array system, constructed using surge current diversion modules. Each module shall be capable of withstanding over 1000 pulses of the 10 kAmps IEEE C62.41 Category C surge current without degradation of clamping voltage. The module shall consist of multiple gap-less metal oxide varistors, with each MOV individually fused. The modules shall be designed and constructed in a manner which ensures reasonable MOV surge current sharing. No gas tubes or silicon avalanche diodes shall be used. The status of each varistor shall be monitored and green LED shall be illuminated if the module is in full working order. When module performance is degraded, such as if one or more fuses or varistors have failed, the LED shall indicate a failed module.

B. Connections: Terminals shall be provided for all of the necessary power and ground connections. The terminals shall accommodate wire sizes of #14 to #2/0 AWG for two conductors per required connection. The units shall use standard parallel wiring techniques.

C. Internal Connections: All surge current diversion module intra-unit connections shall be by way of low impedance busbars or wiring. Surge current diversion modules shall use low impedance connections. All module mounting hardware and power wiring shall be captive or remain in place when a module is removed or replaced.

D. Enclosure: The specified system shall be provided in a heavy duty NEMA 12 dustight, driptight enclosure with no ventilation openings. The cover of the enclosure shall be hinged and require a tool for access to internal components. A drawing pocket shall be provided inside the door for storage of unit drawings and installation/operation manual. Indication of surge current module status shall be visible without opening the door.

E. Integral Test Point: The unit shall incorporate an integral test point allowing easy off-line diagnostic testing which verifies the operational integrity of the unit's suppression/filter system.

2.4 ACCESSORIES:

A. LED indicators shall be provided on the hinged front cover to redundantly indicate unit module status. Additionally, a Form C (one N.O. and one N.C.) summary alarm contact rated for at least 120 VAC and 1 ampere shall be provided for remote annunciation of unit status. The summary alarm contact shall change state if any one or more of the surge current diversion modules has failed.

B. Integral Fused Disconnect Switch: The unit shall include an integral fused and safety interlocked disconnect switch located in the unit enclosure with an externally mounted

manual operator. The switch shall disconnect all ungrounded circuit conductors from the distribution system to enable testing and maintenance without interruption of power to the facility's distribution system. The switch shall be rated for 600 Vac. Each current-carrying ungrounded circuit conductor connected to the facility's distribution system shall be individually fused with 200,000 AIC rated fuses in order to provide maximum fault current protection. The unit shall be UL 1449 Listed with the integral fused disconnect switch and the UL 1449 Suppression Rating for this configuration shall be provided. (1.4.6 Performance Ratings.) Specify Integral Fused Disconnect Switch by adding a "DF" suffix to the model number.

C. Diagnostic Test Set: A Diagnostic Test Set shall be provided which verifies the operational integrity of the unit's suppression system. The Diagnostic Test Set shall be self-contained and portable, and shall provide complete assurance of the unit's installation and capability without stressing the suppression system or posing detriment to continued operation. Specify Diagnostic Test Set as model number DTS 1000.

PART 3 EXECUTION

3.1 INSPECTION:

A. Installer must examine areas and conditions under which SPD equipment is to be installed, and notify contractor in writing of those conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

3.2 INSTALLATION OF SPD EQUIPMENT:

A. Install SPD as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to ensure that SPD installation complies with requirements of NEMA standards and NEC, and applicable portions of NECA’s "standard of installation," for installation of units.

B. Coordinate with other work, including electrical wiring work, as necessary to interface installation of SPD with other work.

C. Install electrical protective devices, if any, for each SPD unit.

D. The installing contractor shall install the parallel SPD with short and straight conductors as practically as possible. The contractor shall twist the SPD input conductors together to reduce input conductor inductance.

E. Field installation: the unit shall be installed as close as practical to the facility's wiring system in accordance with applicable national/local electrical codes and the manufacturer's recommended installation instructions. Connection shall be with #2 awg copper conductor or larger and not be any longer than necessary, avoiding unnecessary bends. Notify engineer prior to installation if unit cannot be installed within manufacturer's required distances.

3.3 ADJUSTING AND CLEANING:

A. Touch-up scratched and marred surfaces of equipment to match original finishes; remove dirt and construction debris.

3.4 FIELD QUALITY CONTROL:

A. Upon completion of installation of SPD equipment and after circuitry has been energized with rated power source. Verify that the equipment is operating properly. Where possible, correct malfunctioning units at site; otherwise remove and replace with new units and re-verify operation.

END OF SECTION 264313

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SECTION 265000 - LIGHTING

PART 1 - GENERAL

1.1 SUMMARY:

A. Extent, location, and details of lighting work are indicated on drawings and in schedules.

B. Types of lighting in this section include the following:

1. Light Emitting Diode (LED)

1.2 SUBMITTALS:

A. Product Data: Submit manufacturer's product data and installation instructions on each type of luminaire and component.

B. Shop Drawings: Submit layout drawings of lighting and their spatial relationship to each other. In addition, submit luminaire cut sheets from the manufacturer *for standard products submit shop drawings; for non-standard (?) products in booklet form with separate sheet for each luminaire, assembled by "luminaire type" with proposed luminaire and accessories clearly indicated on each sheet. Submit details indicating compatibility with ceiling grid system. Shop drawings shall detail luminaire dimensions, weights, methods of field assembly, mounting components, features and accessories. All features and accessories shall be clearly defined.

C. Wiring Diagrams: Submit wiring diagrams for lighting showing connections to electrical power panels, switches, dimmers, controllers, and feeders. Differentiate between portions of wiring which are manufacturer-installed and portions which are field- installed.

D. Samples: Submit one complete operating unit for each type of custom luminaire specified.

E. Maintenance Data: Submit maintenance data and parts list for each luminaire and accessory; including "trouble-shooting" maintenance guide. Include that data, product data, and shop drawings in a maintenance manual; in accordance with general requirements of Division 1.

F. Illumination Data: Submit lighting calculations identified below for all projects not listed first in the luminaire schedule and where otherwise noted.

1. Exterior: Provide isofootcandle (isolux) plot diagram of footcandles on horizontal pavement surface which shows composit values of illuminance projected from the arrangement of light sources from indicated luminaire locations and heights. Show on the graphic plots the locations, spacings, heights of luminaires, and the Lumen Maintenance factor used.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of lighting of sizes, types and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firms with at least 3 years of successful installation experience on projects with lighting work similar to that required for this project.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Deliver lighting in factory-fabricated containers or wrappings, which properly protect luminaires from damage.

B. Store lighting in original packaging. Store inside well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, laid flat and blocked off ground.

C. Handle lighting carefully to prevent damage, breaking, and scoring of finishes. Do not install damaged units or components; replace with new.

1.5 SEQUENCING AND SCHEDULING:

A. Coordinate with other work including wires/cables, electrical boxes and fittings, and raceways, to properly interface installation of lighting with other work.

B. Sequence lighting installation with other work to minimize possibility of damage and soiling during remainder of construction.

1.6 EXTRA MATERIALS:

A. Lenses: Furnish stock or replacement lenses amounting to 3%, but not less than one, of each type and size used in each type luminaire.

B. LED Modules: Furnish replacement modules mounting to 3% of each type.

C. Deliver replacement stock as directed to Owner's storage space.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Luminaire Manufacturers: Subject to compliance with requirements, provide luminaires as listed in the luminaire schedule or elsewhere on the drawings or specification.

B. LED Manufactures:

1. Philips Lighting Co.
2. Lumiled
3. CREE
4. Nichia
5. Osram Sylvania

2.2 EQUIPMENT:

A. General: Provide lighting of sizes, types and ratings indicated; complete with, but not limited to, housings, energy-efficient lamps, lamp holders, reflectors, energy efficient ballasts, starters and wiring. Ship luminaires factory-assembled, with those components required for a complete installation. Design luminaire with concealed hinges and catches, with metal parts grounded as common unit, and so constructed as to dampen ballast generated noise and as to disconnect ballast when door is opened for HQI lamps.

B. Wiring: Provide electrical wiring within luminaire suitable for connecting to branch circuit wiring as follows:

1. NEC Type TFN for 120 and 277 volt and shall be minimum No. 18 AWG.

C. Lamps:

1. Provide LED's that retain 70% of lamp life after 50,000 hours. LED's shall be binned to NEMA standard SSL 3-2010. *Indoor luminaires shall have remote phosphors. The LED light assembly shall be replaceable separate from the luminaire housing. The LED driver shall be dimming where indicated on the drawings. The dimmer switch shall be compatible with the driver, unless otherwise noted.*

a. Indoor luminaires shall have remote phosphor technology for "white" LED's.

b. All LED products to be in accordance with IES Standards LM79 & LM80.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine areas and conditions under which lighting is to be installed, and substrate for supporting lighting. Notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION:

A. Install lighting at locations and heights as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC, NECA's "Standard of Installation", NEMA standards, and with recognized industry practices to ensure that lighting fulfills requirements.

B. Provide luminaires and/or outlet boxes with hangers to properly support luminaire weight. Submit design of hangers, method of fastening, other than indicated or specified herein, for review by Architect.

1. Luminaires shall be positively attached to the suspended ceiling system. The attachment device shall have a capacity of 100% of the luminaire weight acting in any direction.

2. When intermediate systems are used, No. 12 gauge hangers shall be attached to the grid members within 3" of each corner of each luminaire.

3. When heavy-duty systems are used, supplemental hangers are not required if a 48" modular hanger pattern is followed. When cross runners are used without supplemental hangers to support luminaires, these cross runners shall provide the same carrying capacity as the main runner.

4. Luminaires weighing less than 56 pounds shall have, in addition to the requirements above, two No. 12 gauge hangers connected from the luminaire housing to the structure above. These wires may be slack.

5. Luminaires weighing 56 pounds or more shall be supported directly from the structure above by four No. 12 gauge hangers connected from the luminaire housing to the structure above. These wires may be slack.

C. Install flush mounted luminaires properly to eliminate light leakage between frame and finished surface.

D. Provide plaster frames for recessed luminaires installed in other than suspended grid type acoustical ceiling systems. Brace frames temporarily to prevent distortion during handling.

E. For air supply type troffers, retain side slot closures in place for adjustment by Balancing Contractor.

F. Fasten luminaires securely to structural supports; and ensure that pendant luminaires are plumb and level. Provide individually mounted pendant luminaires longer than 2 feet with twin stem hangers. Provide stem hanger with ball aligners and provisions for minimum one inch vertical adjustment. Mount continuous rows of luminaires with an additional stem hanger greater than number of luminaires in the row.

1. Pendant hung luminaires shall be supported directly from the structure above with No. 9 gauge wire or approved alternate support without using the ceiling suspension system for direct support.

2. Luminaires mounted in areas of high seismic activity shall be mounted from a rigid stem to restrain sway. If mounted from a non-rigid stem, luminaires to be mounted such that their sway under seismic conditions does not impact another luminaire within 45˚ swing from nadir.

G. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Stds 486A and B, and the National Electrical Code.

H. Support surface mounted luminaires greater than 2 feet in length at a point in addition to the outlet box stud.

I. Set units plumb, square, level and secure according to manufacturer's written instructions and shop drawings. Refer to specification section 265613, "Poles and Standards" for other requirements.

3.3 FIELD QUALITY CONTROL:

A. Replace defective and burned out lamps for a period of one year following the Date of Substantial Completion.

3.4 ADJUSTING AND CLEANING:

A. Clean lighting of dirt and construction debris upon completion of installation. Clean fingerprints and smudges from lenses and reflectors.

B. Protect installed luminaires from damage during remainder of construction period.

C. Adjust aimable luminaires to provide required light intensities and in compliance with design intent.

3.5 GROUNDING:

A. Provide equipment grounding connections for lighting as indicated. Tighten connections to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounds.

B. Ground luminaires according to Section 260526, "Grounding," and Section 265613, "Poles and Standards."

3.6 WARRANTY

A. The Contractor shall guarantee all equipment including ballasts, lamps, luminaires, wiring, etc. free from inherent mechanical and electrical defects. Warranty period shall be from date of acceptance as set forth in the general conditions with periods as follows:

1. Lamps - Per Paragraph 3.3
2. Luminaires, wiring, etc. - 1 year
3. Ballasts - The manufacturer shall provide a full five year warranty beginning at time of substantial completion. The manufacturer shall replace any and all failed ballasts within 48 hours of notification. The manufacturer shall provide the labor for warranty replacements.
4. LED and Driver – Five year manufacturer's warranty.

3.7 DEMONSTRATION:

A. Upon completion of installation of lighting and after building circuitry has been energized, apply electrical energy to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

END OF SECTION 265000

SECTION 267400- ELECTRICAL FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes electrical work required to support the Communications Systems specified in Division 27 and 28 (Security Systems).

1.2 DESCRIPTION OF WORK

A. The Electrical Contractor shall provide electrical work and equipment as called for in the following Division 27 Specification Sections.
   1. Basic Communications Requirements
   2. Bidding
   3. Quality Assurance
   4. Common Work - Sleeves, Penetrations, and Firestopping
   5. Common Work - Hangers and Supports
   6. Electrical Technology - General Requirements
   7. Electrical Technology - Grounding and Bonding
   8. Electrical Technology - Conduit and Boxes
   9. Electrical Technology - Underground Ducts and Raceways
   10. Electrical Technology - Maintenance and Hand Holes

B. The requirements of these Sections are additional to, different from, or otherwise supplement the requirements of similar work specified in Division 26.

C. The requirements of these Sections serve as the basis for the requirements of this Section, and are incorporated by reference into this specification Section.

PART 2 - MATERIALS

2.1 THIS SECTION NOT USED

PART 3 - EXECUTION

3.1 THIS SECTION NOT USED

END OF SECTION 267400

SECTION 270010 - BASIC COMMUNICATIONS REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies the basic requirements for Communications Systems installations as indicated or required, and includes requirements common to more than one Specification Section of this Division (such as related documents, related Sections, definitions, governing requirements, Contractor requirements, warranty requirements, submittal requirements/procedures, and project closeout requirements/procedures, as well as other requirements).

1.2 RELATED DOCUMENTS

A. The General Requirements of the Contract (including General and Supplementary Conditions, and the requirements of Division 1), apply to the work of this Division.

B. This Section may expand upon or supplement the General Requirements of the Contract. In the event of a conflict or discrepancy between this Section and the General Requirements of the Contract, the General Requirements of the Contract shall govern. However, if the requirement of this Section (or portion thereof) exceeds that of the General Requirements of the Contract, and is furthermore not contrary to the General Requirements of the Contract, then the requirement of this Section (or portion thereof) shall prevail.

C. Examine the Construction Documents in their entirety (including Drawings and Specification Sections in the other Divisions) for requirements or work which may affect work under this Section, regardless of whether such requirements or work are specifically indicated in this Section.

1.3 RELATED SECTIONS

A. All Specification Sections in this Division.

B. The following Sections in other Divisions:
   1. Division 26 – Electrical for Communications Systems
   2. Division 28 – Security Systems

1.4 COMMUNICATIONS SYSTEMS

A. The following Communications Systems are included within this Division or within Division 28 and included on the Communications (T-series) Construction Drawings. Refer to paragraph *DEFINITIONS* later in this Specification Section for further explanation of each system:
   1. Audiovisual System.
   2. Communications Cabling System.
   3. Electrical for Communications Systems.

4. Security System(s).
5. Network System(s).

1.5 INTENT AND INTERPRETATIONS

A. It is the intent of the Construction Documents that the Contractor shall include all items necessary for the proper execution and completion of the Work by the Contractor, resulting in complete and fully operational system(s) ready for the Owner's use, in full compliance with all applicable standards, codes and ordinances.
   1. Work or product not specifically indicated in the Construction Documents, but which are necessary to result in complete and fully operational system(s) ready for the Owner's use, shall be provided by the Contractor.
   2. The specification of certain products in the Construction Documents shall not be construed as a release from furnishing such additional products and materials necessary to furnish complete and fully operational system(s) ready for the Owner's use.

B. The Construction Documents include certain conventions in the use of language and the intended meaning of certain terms, words, and phrases when used in particular situations or circumstances. These conventions include:
   1. Abbreviated Language: Language used may be abbreviated. Implied words and meanings shall be interpreted as appropriate. Words implied, but not stated, shall be interpreted as the sense requires. Singular words shall be interpreted as plural and plural words interpreted as singular where applicable and where the full context so dictates.
   2. Imperative and Streamlined Language: Imperative and streamlined language is used generally. Requirements expressed in the imperative mood are to be performed by the Contractor. At certain locations in the text, for clarity, subjective language is used to describe responsibilities that must be fulfilled indirectly by the Contractor, or by others when so noted.
   3. Abbreviations and Names: Trade association names and titles of general standards are frequently abbreviated. Where abbreviations and acronyms are used, they mean the recognized name of the trade association, standards generating organization, authority having jurisdiction, or other entity applicable to the context.
   4. Words used in the singular shall also mean the plural, wherever the context so indicates, and likewise words in the plural shall also mean the singular, wherever the context so indicates.
   5. Unless otherwise stated, words which have well known technical or construction industry meanings are used in accordance with such recognized meanings.
   6. The terms "directed", "required", "permitted", "ordered", "designated", or "prescribed", as well as similar words shall mean the direction, requirement, permission, order, designation or prescription of the Engineer.
   7. The terms "approved", "acceptable", "satisfactory", and similar words shall mean approved by, acceptable, or satisfactory to the Engineer.
   8. The terms "necessary", "reasonable", "proper", "correct" and similar words shall mean necessary, reasonable, proper, or correct in the judgment of the Engineer.

C. Assignment of Specialists: The individual Specification Sections may require that certain specific construction activities be performed by specialists who are recognized experts in the operations to be performed. The specialists must be engaged for those activities, and such assignments are requirements over which the Contractor has no choice or option. Nevertheless, the ultimate responsibility for fulfilling the contract requirements shall remain with the Contractor.
   1. This requirement shall not be interpreted to conflict with the enforcement of local building codes and similar regulations governing the work.

D. Drawings:
   1. Drawings are diagrammatic and approximate in character, are not intended to show all features of required work, and do not necessarily indicate every required component.
   2. Symbols used on the Drawings are defined in the legend on the Drawings. Symbols indicated on the legend may not necessarily be required.

E. Drawings and Specifications are complementary. Items required by either are binding as though they are required by both.

1.6 DEFINITIONS

A. The definitions below are applicable to this Division:
   1. General
      a. Accepted/Acceptable: Work or materials conforming with the intent of the project, and in general, conforming to the pertinent information in the Construction Documents.
      b. Approved/Approval: The written approval of the Engineer.
      c. Accessible: Easy access. Access attained without requiring extensive removal of other materials to gain access.
      d. Accessible Ceiling: Acoustical tile hanging ceilings ("Hard-lid" ceilings (concealed spine or sheetrock/gypsum ceilings), even when provided with access panels, are not considered an Accessible Ceiling.)
      e. Agreement: The contractual agreement between the Owner and the Contractor.
      f. By Others: A party or entity other than the Contractor. The Contractor shall engage the General Contractor, Architect, and/or Owner to determine this party or entity for consideration of pricing and/or execution of the Work.
      g. Concealed: Hidden from sight in interstitial building spaces, chases, furred spaces, shafts, crawl spaces, etc.
      h. Construction Documents: Collective term for the entire set of bound or unbound material describing the construction and services required, including all Drawings, Specifications, addenda issued prior to execution of the contract, and modifications issued after execution of the Contract (such as change orders, construction change directives, supplemental instructions, etc.).
      i. Contract Documents: The Agreement (including other documents listed in the Agreement), Conditions of the Contract (General, Supplementary and other conditions), and the Construction Documents.

j. The Contract: The Contract Documents form the Contract. The Contract represents the entire and integrated agreement between the Owner and the Contractor and supersedes any prior negotiations, representations or agreements, either written or oral. The Contract shall not be construed to create a contractual relationship of any kind (1) between the Engineer and the Contractor, (2) between the Owner and a subcontractor, or (3) between any persons or entities other than the Owner and Contractor.

k. Contractor: The party responsible for providing the Communication System(s) as indicated herein.

l. Drawings: The graphic and pictorial portions of the Contract Documents, wherever located and whenever issued, showing the design, location and dimensions of the Work, generally including (but not limited to) plans, elevations, sections, details, schedules and/or diagrams.

m. Engineer: The party responsible for producing the Communication System(s) Construction Documents.

n. Exposed: Not concealed (see above) and not installed underground.

o. Final Completion: The date when the Engineer confirms in writing that the Contractor has completed the work in accordance with the Construction Documents, including completion of all punch list items, cleanup work and delivery of all required guarantees, warranties, licenses, releases and other required deliverables.

p. Furnish: To purchase, supply, and deliver to the project materials in new and operable condition, ready for installation.

q. Governing Requirements: Collective term for regulations, laws, ordinances, codes, rules, standards, requirements, guidelines, and recommendations that govern the installation and inspection of the work defined in the Contract Documents.

r. Governing Authority: Entities or their representatives charged with formation and/or enforcement of Governing Requirements, such as the Authority Having Jurisdiction (AHJ).

s. Install: To place in final position in fully operable, tested condition.

t. Inside Plant (ISP): Infrastructure within a building.

u. Or Equal: Materials approved for use by the Engineer and which are dimensionally suitable and operationally identical to the specified item.

v. Outside Plant (OSP): Infrastructure exterior to a building.

w. Owner: The Owner and the Owner's designated representative(s).

x. The Project: The total construction of which the Work performed under the Contract Documents may be the whole or a part, and which may include construction by the Owner and/or separate Contractors.

y. Provide: To furnish and install, complete, tested and ready for intended use.

z. Rough-in: Provide the Communications Pathway System, including (but not limited to) device boxes, pull boxes, wall boxes, floor boxes, poke-through devices, conduit, enclosures, cable tray, ducts/ductbanks, maintenance holes, hand holes, and other pathways and items indicated (or as required) for routing, supporting, and installing communications cables, devices, or equipment which shall be provided by others or provided under a subsequent set of Contract Documents.

aa. Substantial Completion: The date when all work required by the Construction Documents shall be complete (subject to the final punch list to be prepared by the Engineer) and on which the applicable jurisdictional authorities have issued a temporary certification of occupancy.

bb. Section: An individual Section of the Specifications.

cc. Shown on Drawings: Noted, indicated, scheduled, detailed, or any other written reference made on the Drawings.
dd. Specifications: The portion of the Contract Documents consisting of the written requirements for materials, equipment, construction systems, standards and workmanship for the Work and performance of related services.
ee. Specification Section(s): One or more Sections of the Specifications.
ff. Section(s): An abbreviated form of Specification Section(s).
gg. The Work: The construction and services required by the Contract Documents, whether completed or partially completed, and all other labor, materials, equipment and services provided or to be provided by the Contractor to fulfill the Contractor's obligations. The Work may constitute the whole or a part of the Project.

2. Communications Systems
   a. Audiovisual System: Includes (but is not limited to) audiovisual cables, connectors, terminations and termination equipment, audiovisual equipment, equipment racks, equipment required for system configuration, programming and testing, and other incidental and miscellaneous product and labor as required.
   b. Communications Cabling System: Includes (but is not limited to) communications cables and patch cables, connectors, terminations and termination equipment and panels, equipment racks and distribution equipment, equipment required for the build-out of communications rooms and spaces, cable support equipment not covered under Communications Pathway System including, but not limited to J-hooks/Straps, and other incidental and miscellaneous product and labor as required.
   c. Communications Infrastructure System: A Communications Cabling System in conjunction with a Communications Pathway System.
   d. Electrical for Communications Systems:
      1) Communications Pathway System: Includes (but is not limited to) device boxes, pull boxes, conduit, cable tray, duct/ductbank, and other pathway and raceway components necessary to provide pathway for, support, and route cables for Communications Systems.
      2) Telecommunications Grounding and Bonding System: Includes (but is not limited to) providing a permanent grounding and bonding infrastructure for the Communications Cabling System.
      3) Commonly referred to as Electrical Technology in the Division 27 Construction Documents.
   e. Low Voltage System(s): Includes (but is not limited to) low-voltage cables, connectors, terminations and termination equipment, equipment, equipment racks, equipment required for system configuration, and testing, and other incidental and miscellaneous product and labor as required.
      1) In-Building Wireless System (IWS): Includes (but is not limited to) cabling and equipment used to enhance in-building radio operation by allowing radio frequency signals from outside the building to be re-radiated within the building, and vice-versa.
   f. Security System(s): Includes (but is not limited to) security cables, connectors, terminations and termination equipment, security equipment, equipment racks, equipment required for system configuration, programming and testing, and other incidental and miscellaneous product and labor as required.
   g. Structured Cabling System (SCS): Alternative term for Communications Cabling System.

1.7 ABBREVIATIONS

A. Refer to the individual Specification Sections and Drawings for abbreviations and their definitions.

1.8 GOVERNING REQUIREMENTS

A. All work shall be executed in compliance with the applicable portions of the following Governing Requirements:
   1. General
      a. ACI: American Concrete Institute (www.aci-int.org)
      b. ADA: Americans with Disabilities Act
      c. AHJ: Authority Having Jurisdiction
      d. ANSI: American National Standards Institute (www.ansi.org)
      e. ASTM: American Society for Testing and Materials (www.astm.org)
      f. BELLCORE: Bell Communications Research (www.telecorrdia.com)
      g. BICSI: A Telecommunications Association (www.bicsi.org)
      h. ETL: Electrical Testing Laboratories
      i. IBC: International Building Code
      j. ICEA: Insulated Cable Engineers Association (www.icea.net)
      k. IEEE: Institute of Electrical and Electronic Engineers (www.ieee.org, www.standards.ieee.org)
      l. IES: Illuminating Engineering Society of North America (www.iesna.org)
      m. Electrotechnical Commission (www.iso.ch, www.iec.ch)
      n. FCC: Federal Communications Commission Rules and Regulations
      o. NAB: National Association of Broadcasters
      p. NFPA: National Fire Protection Association (www.nfpa.org)
      q. NEC: National Electrical Code (NFPA Article 70) (www.nfpa.org, www.necdirect.org)
      r. NESC: National Electrical Safety Code (http://standards.ieee.org/nesc/)
      s. NEMA: National Electrical Manufacturers Association (www.nema.org)
      t. NIST: National Institute of Standards and Technology (www.nist.gov)
      u. OSHA: Occupational Safety and Health Administration (www.osha.gov)
      v. RUS: Rural Utilities Service (http://www.usda.gov/rus/)
      w. TIA: Telecommunications Industry Association (www.tiaonline.org)
      x. UBC: Uniform Building Code
      y. UFC: Uniform Fire Code (www.nfpa.org)
      z. UL: Underwriters Laboratories, Inc. (www.ul.com, www.ulstandardsinfonet.ul.com)
      aa. State and local codes, ordinances, and regulations
      bb. Requirements and guidelines of local utility companies
      cc. Applicable state, local and/or federal laws, regulations, and/or specifications
      dd. Manufacturer installation requirements, guidelines and recommendations
   2. Communication System Specific: The following portions of the General Governing Requirements above are particularly relevant to a given Communications System. Omission from this list does not alleviate the Contractor from responsibility for executing all Work for all Communications Systems in compliance with all applicable portions of the Governing Requirements above:
      a. Communications Cabling System:
         1) TIA 568: Commercial Building Telecommunications Cabling Standard

2) TIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
3) TIA 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
4) ANSI/NECA/BICSI 607: Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings
5) ANSI J-STD-607: Commercial Building Grounding and Bonding Requirements for Telecommunications
6) TIA 758: Customer-owned Outside Plant Telecommunications Cabling Standard
7) ANSI 310-D: Cabinets, Racks, Panels and Associated Equipment
8) ANSI/TIA 942: Telecommunications Infrastructure Standard for Data Centers
9) TIA: Technical Service Bulletins (TSBs) (related to the above TIA standards)
10) IEEE 802.3 (series): Local Area Network Ethernet Standards
11) BICSI: Customer Owned Outside Plant Design Manual
12) BICSI: Information Transport Systems Installation Manual
13) BICSI: Network Design Reference Manual
14) BICSI: Telecommunications Distribution Methods Manual
15) BICSI: Wireless Design Reference Manual
16) NFPA 70: NEC: National Electrical Code (NFPA Article 70)
17) NFPA 75: Protection of Electronic Computer and Data Processing Equipment
18) NFPA 78: Lightning Protection Code
19) FCC Part 68: Connection of Terminal Equipment to Telephone Network.
20) FCC Part 76.611: CFR Title 47 Radiation Leakage Standards

b. Electrical for Communications Systems:
1) TIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
2) TIA 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
3) ANSI/NECA/BICSI 607: Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings
4) ANSI J-STD-607: Commercial Building Grounding and Bonding Requirements for Telecommunications
5) TIA 758: Customer-owned Outside Plant Telecommunications Cabling Standard
6) ANSI/TIA 942: Telecommunications Infrastructure Standard for Data Centers
7) TIA: Technical Service Bulletins (TSBs) (related to the above TIA)
8) BICSI: Customer Owned Outside Plant Design Manual
9) BICSI: Telecommunications Cabling Installation Manual
10) BICSI: Telecommunications Distribution Methods Manual
11) NFPA 70: NEC: National Electrical Code (NFPA Article 70)
12) NFPA 75: Protection of Electronic Computer and Data Processing Equipment
13) NFPA 78: Lightning Protection Code
14) UL 467: Grounding and Bonding Equipment

c. Low-Voltage System(s):

d. In-Building Wireless System:
   1) ANSI/BICSI 006-2015, Distributed Antenna System (DAS) Design and Implementation Best Practices.

e. Security System(s):
   1) IBC: International Building Code
   2) NFPA 72: National Fire Alarm and Signaling Code
   3) NFPA 731: Standard for the Installation of Electronic Premises Security Systems
   4) NFPA 101: Life Safety Code
   5) UL 294: Standard for Access Control System Units
   6) UL 1076: Proprietary Burglar Alarm Units and Systems
   7) UL 2900-2-3: Software Cybersecurity for Network-Connectable Products

B. Nothing in the Governing Requirements and Construction Documents shall be construed to permit work not conforming to all governing codes and regulations.

C. Errors or omissions in the Construction Documents do not relieve the Contractor from executing the work in accordance with the Governing Requirements, including all governing codes and regulations.

D. The applicable portions of the Governing Requirements shall be incorporated by reference into each related Specification Section in this Division.

1.9 PERMITS AND FEES

A. The Contractor shall obtain and pay for all licenses, permits and inspections required by the laws, ordinances and rules governing work specified herein. Such fees shall be included in the bid amount.

B. The Contractor shall pay all fees, including but not limited to fees for local utility service installation, connection charges, etc. Such fees shall be included in the bid amount.

C. Notations on permit or review documents shall be observed. Additional requirements noted by the Governing Authority shall be made part of the requirements for construction of the Project. Additional costs for implementing these requirements, if any, shall be submitted for review prior to construction.

D. Engineering Fees: The Specifications may identify work required of the Engineer due to improper action(s), lack of action(s), and/or deficiencies on the Contractor's part. Such instances will be identified in the Specifications and the Contractor shall be responsible for these fees if they are incurred by the Engineer.
   1. Fees charged to the Contractor will be at the Engineer's billing rates at the time the services are performed. Travel time will be included, if applicable. Mileage will be charged for required automobile travel at the standard IRS mileage rate in effect at the time the services were performed. Expenses will be billed at cost plus 10 percent markup.
   2. Fees will either be paid directly to the Engineer or will be deducted directly from payments (or the final payment) to the Contractor.

1.10 SUBSTITUTIONS AND DEVIATIONS

A. The requirements below expand upon and/or supplement the requirements in Division 1.

B. Substitution of product and deviations from the methods of construction specified which are used in the Contractor's bid shall be at the sole risk of the Contractor, and as such are subject to rejection without consideration.

C. Proposed substitution and deviation requests shall be reviewed during the time of Submittal review:
   1. Conditions for Consideration: Substitution and deviation requests will be received and considered only when one or more of the following conditions are satisfied:
      a. A substantial advantage is offered to the Owner, in terms of cost, time, or other considerations of merit.
      b. The specified product or method of construction cannot be provided with the contract period.
      c. The specified product or method of construction cannot receive necessary approval by a Governing Authority, and the requested substitution can be approved.
      d. The specified product or method of construction cannot be provided in a manner that is compatible with other materials.
      e. The specified product has been discontinued or recalled by manufacturer, or has become technologically obsolete. In such cases, the substituted equipment shall be of like manufacturer, make, and model as specified product when possible.
      f. The manufacturer of specified product has ceased business practices.
      g. The product as specified includes the statement, "Or Equal."
   2. Conditions for Rejection: Substitution and deviation requests will be rejected for the following reasons, among others:
      a. The conditions for consideration (see above) have not been met.
      b. Extensive revisions to the Construction Documents are required to support the proposed changes.
      c. The proposed changes do not comply with the general intent of the Construction Documents.
      d. The substitution request is for product which does not include the statement, "Or Equal", or is specified as "no substitute", "substitutions are not acceptable", "provide as specified" or similar.
      e. The substitution and deviation is not of equal or greater value as specified product or design.
      f. The proposed change is solely for the convenience or economic gain of the Contractor.

D. The Contractor shall not proceed with procurement or installation of a substitution or deviation without written approval.
   1. Upon approval of the request, the Contractor shall be responsible for fees incurred by the Engineer for re-design work or modifications to the Construction Documents if necessitated by the nature of the request.

1.11 SUBMITTALS

A. The requirements below expand upon and/or supplement the requirements in Division 1.

B. Provide product data submittals for all equipment to be provided in which a manufacturer and part number have been listed on the equipment schedule(s) on the technology construction drawings.

C. General:
   1. Submittal review is a courtesy extended to the Contractor for the limited purpose of checking for general conformance with the design concept and the information shown in the Construction Documents.
   2. Prior to submission of any product or methods of construction submittal items, submit a Submittal Schedule indicating items to be submitted with respective dates. Schedule shall allow the Engineer's possession of each submittal for a minimum of two week(s). Schedule shall clearly indicate submittal items that will contain a "Substitution and Deviation Requests" section (see below) including a statement indicating condition for consideration of such as listed under requirements of *Part 1 – General: Substitutions and Deviations* herein.
   3. The Contractor shall provide submittal information as soon as practicable after the date of Notice to Proceed and prior to the purchase, delivery, fabrication, and installation of product and materials.
   4. In the event of discrepancies or conflict between Submittals and the Construction Documents, either prior to or after review, the requirements of the Construction Documents shall prevail.
   5. Submission of material for review, regardless of the outcome of the review, does not alter the Contractor's obligation to follow the intent of the Construction Documents, nor the Contractor's responsibility to comply with the Construction Documents.
   6. Submittals will not be reviewed and will be returned to the Contractor without review for the following reasons:
      a. Submittal package does not conform to the requirements listed herein.
      b. Submittal is for a product or method of construction not required by the Construction Documents.
      c. Submittal is partial or incomplete. For example, a submittal shall be considered partial or incomplete if Product Data is not accompanied by related Shop Drawings.
      d. Submittal contains information concerning the proposed implementation of means, methods, procedures, sequences or techniques, temporary aspects of the construction process, or other items, which are the sole responsibility of the Contractor.
      e. Submittal was not carefully reviewed by the Contractor prior to submission, as evidenced by poor organization, obvious or numerous errors, lack of correlation or cross-referencing, lack of clarity in presentation, or containing Shop Drawings which do not meet the standard of the Construction Drawings.
      f. Submittal was submitted directly from the Contractor's subcontractor(s) or vendor(s).
      g. Subcontractor and/or vendor submittal information was not carefully reviewed and/or approved by the Contractor.
      h. Submittal does not bear the Contractor's approval stamp, and/or contains subcontractor and/or vendor submittal information which does not bear the Contractor's approval stamp.
      i. Submittal contains substitution and/or deviation requests, which are not clearly identified as substitution or deviation requests in a separate "Substitution and Deviation Requests" section of the Submittal.

7. Submittals shall be submitted as a single package and shall include subcontractor and vendor submittal information.
8. Each submittal (or re-submittal) set shall bear a unique Contractor's submittal sequence number.
9. Requests for substitution shall only be included under the "Substitution and Deviation Requests" section of the submittal (see below) and shall comply with the requirements of *Part 1 – General: Substitutions and Deviations* herein. Submission of substitution requests in any other portion of the Submittal does not constitute an acceptable or valid request for substitution, nor will review of such information constitute approval in any manner.

D. Submittal Format:
1. Submittals shall be bound in one letter-sized (8-1/2 inch by 11 inch) document and under separate cover from submittals furnished under other Divisions.
2. Front cover of Submittal shall indicate the name of the project, the project number, the name of the Owner, year of completion, the title "Communications Submittals", and the names of the Engineer and Contractor, as well as the General Contractor.
3. Submittals shall include a table of contents identifying sections, Specification Sections, and page numbers.
4. Information provided in the submittal shall follow the same general order of the Specifications.
5. Submittals shall be sectionalized (Indexed with titled tab dividers (by section name – not numbered and not handwritten).
   a. Sections shall be (see Submittal Sections below for more detail regarding each section):
      1) Product Data
      2) Shop Drawings
      3) Substitution and Deviation Requests
      4) Test Reports
      5) Other Information
   b. Within each section, information shall be organized by Specification Section and/or Drawing to which the information applies.
   c. Within each section, where section is not applicable (e.g. shop drawings, technical drawings, etc.), the section shall include a page denoting same.
6. Pages shall be numbered.
7. Drawings (except for full and half-size Shop Drawings), if not in 8-1/2 inch by 11 inch size, shall be bound and accordion folded to 8-1/2 inch by 11 inch size.
8. Quantity: Submit copies in quantities per the requirements of Division 1.
9. Quantity: Submit 6 copies of the Submittal.

E. Submittal Sections: Submittals shall be sectionalized and shall include sections for Product Data, Shop Drawings, Substitution and Deviation Requests, and Other Information (see Submittal Format herein).
1. Product Data: Submit Product Data information as called for in the individual Specification Sections. Product Data shall include:
   a. For all product, provide the following product information (as applicable):
      1) Specification Section to which the product applies.
      2) Catalog cut sheets, manufacturer data sheets, and/or specification sheets detailing the product, item, assembly and installation.
      3) Manufacturer's printed recommendations (if not included in the above).
      4) Written description.

5) Notation of dimensions verified by field measurement.
6) Notation of coordination requirements.
7) Compliance with recognized trade association and testing agency standards.
8) Highlighted details within the product data that identifies compliance with the Construction Documents or the intent of the Construction Documents.
9) Highlighted details within the product data that identifies deviations from the Construction Documents or the intent of the Construction Documents.

b. For products for which the Contractor is proposing a substitution, include the product as specified in the Submittal per the above requirements and list the reference to the proposed substitution in the "Substitution and Deviation Requests" section of the Submittal (see below).

c. Do not provide product quantities – quantities are the sole responsibility of the Contractor and will not be reviewed.

2. Shop Drawings: Submit Shop Drawings that are newly prepared, drawn to accurate scale, and that fully illustrate the Contractor's understanding of the intent and requirements of the Construction Documents (i.e. Shop Drawings shall not be based upon or consist of a reproduction of the Construction Documents or standard printed data). Submit Shop Drawings as called for in the individual Specification Sections. Shop Drawings shall include:

a. Identification of products and materials

b. Schedules, including but not limited to:
1) Equipment and components
2) Cables: identify manufacturer, model number, outside diameter and connector

c. Notation of coordination requirements

d. Notation of dimensions established by field measurement

e. Notation of details that identify compliance with the Governing Requirements

f. Notation of details that identify compliance with the Construction Documents or the intent of the Construction Documents.

g. Notation of deviations from the Construction Documents or the intent of the Construction Documents. *Highlight, encircle, or otherwise clearly indicate such deviations*

h. Roughing-in and setting diagrams

i. Fabrication, installation, and adaptation details including, but not limited to:
1) Electronic equipment to be mounted within racks
2) Cable routing between electronic equipment in racks or housings
3) Equipment to be mounted within furniture
4) Wall and ceiling mounted devices
5) System labels, including but not limited to engraved, lamacoid, silk screen and paper labels
6) Suspended loudspeaker mounting, including but not limited to tilt angle, splay angle, height above finished floor, coverage pattern, and assembled weight
7) Non-standard manufactured or adapted equipment
8) Dimensions
9) Other details as necessary to establish the intent of the Construction Documents

j. One-line diagrams detailing the interconnections of system components, including the identification of all devices, cabling, terminations, and termination techniques as required for fully functional systems

k. Applicable software block diagrams representing the internal operation of devices such as, but not limited to, control processors and digital signal processors
l. Templates
m. Floor plans identifying equipment locations, *if not shown on the Construction Documents*
n. Reflected ceiling plans identifying equipment locations, *if not shown on the Construction Documents*
o. Indication of sectionalized manufacturing of equipment (i.e. for oversized equipment that cannot be installed as a single component).
p. Shop drawings shall be provided in form, format and size identical to that of the Construction Drawings (the Construction Drawings set the standard). Shop Drawings that do not meet this standard shall be rejected without review.
    1) Title Block: May be the Contractor's Title Block, but shall indicate Project name, manufacturer's name and logo, date of submittal, content of sheet, and sheet number.
    2) Floor Plans: Plan titles, scales, north arrows, column lines, line types, fonts, and room names and numbers shall match that of the Construction Drawings.
q. For methods of construction for which the Contractor is proposing a deviation, include the method of construction as specified per the above requirements and list the reference to the proposed deviation in the "Substitution and Deviation Requests" section of the Submittal (see below).

3. Substitution and Deviation Requests: For each substitution and/or deviation request, include the following:
    a. Whether the request is for substitution of product or a deviation from a construction method.
    b. The Specification Section(s) or Drawing to which the request applies.
    c. Reason for the request. (Note: the reason must conform to the requirements of *Part 1 – General: Substitutions and Deviations* herein.)
    d. If a substitution, provide:
        1) Specified product to which the proposed substitution applies.
        2) Product Data for the substituted product.
        3) Notation of differences between the proposed substitution and the specified item. *Highlight, encircle, or otherwise clearly indicate the substitution.*
    e. If a deviation, provide:
        1) Specified Drawing and/or method of construction to which the proposed deviation applies.
        2) Shop Drawings showing the deviation.
        3) Notation of differences between the proposed deviation and the specified drawing and/or construction method. *Highlight, encircle, or otherwise clearly indicate the deviation.*
    f. Written statement signed by the Contractor stating that the proposed substitution or deviation is equivalent or superior in function, appearance, and quality to the specified product or construction method and that the proposed substitution or deviation will be at no additional cost to the Owner.
4. Test Reports:
    a. Submit full-size mock-ups of the test reports that will be used to document the testing.
5. Other Information:
    a. Contractor Statement of Qualifications, per Division 27 Specification Section *Contractor Qualifications.*

b. Bid Form or Bid Supplement Form, per Division 27 Specification Section *Bidding*.
c. Submit additional information as called for in the individual Specification Sections.

F. Submittal review:
1. The submittal review will not include review of the accuracy or completeness of details, such as quantities, dimensions, weights or gauges, fabrication processes, construction means or methods, coordination of work with other trades, or construction safety precautions, all of which are the sole responsibility of the Contractor.
2. Corrections or comments made on the Submittal by the reviewer during the submittal review do not relieve the Contractor from compliance with the requirements of the Construction Documents.
3. Review of a specific item shall not indicate that the reviewer has reviewed the entire assembly of which the item is a component.
4. Review does not relieve the Contractor from responsibility for errors, which may exist in the submitted data.
5. Review of substitutions and deviations:
   a. The reviewer shall not be responsible for review of substitutions and/or deviations that were not brought to the attention of the reviewer by specific inclusion of the substitution and/or deviation in the Substitution and Deviation Requests section of the Submittal.
   b. Where a substitution and/or deviation is not included in the Substitution and Deviation Requests section of the Submittal, the procurement and installation of the substitution and/or deviation is at the sole risk of the Contractor.
   c. If the reviewer does not specifically note substitutions and/or deviations, it remains the Contractor's responsibility to comply with the Construction Documents.
6. After review, submittals shall be returned together with review comments and specific actions (if required) to be taken by the Contractor. Typical comments and actions will be:
   a. Reviewed - resubmittal not required
   b. Rejected - resubmittal required
   c. Revise and Resubmit - resubmittal required
   d. Make Corrections as Noted - resubmittal not required
7. The Contractor shall perform no portion of the Work requiring a submittal until the respective submittal has been reviewed and approved. Such Work shall be in accordance with the approved submittal.

G. Re-submission of submittals:
1. Submittals shall continue to be re-submitted and reviewed until all submitted items are marked by the Engineer as 'No Exceptions Taken' or 'Revise - Re-submittal Not Required'.
2. Re-submittals shall be clearly identified as a re-submittal and shall identify changes on a separate Revisions page inserted after the Table of Contents page(s).
3. The Contractor shall be responsible for fees incurred by the Engineer resulting from subsequent review of re-submittals that fail to meet the requirements herein. Such fees will be incurred after the Engineer has reviewed the original submission and one re-submission.
4. Re-submittals do not entitle the Contractor to additional time, nor are they considered cause for delay of the project.

1.12 RECORD DOCUMENTS

A. The requirements below expand upon and/or supplement the requirements in Division 1.

B. The Contractor shall maintain a set of Record Documents showing all additions, changes, and deletions that have been made to the original Drawings and Specifications throughout the course of construction, as well as reviewed Submittal data, including but not limited to Shop Drawings.
   1. Items to be noted shall include but shall not be limited to:
      a. Final device box, pull box, floor box, sleeve and conduit stub/ poke thru locations
      b. Final locations, sizes, and dimensions of equipment, including concealed equipment
      c. Routing of concealed raceways/pathways
      d. Raceways/pathways located more than 2 feet from where shown on the original Construction Documents
      e. Raceways and main pathways (pathways with more than 30 cables) not shown on the Drawings
      f. Building outline changes
      g. Addenda, accepted Alternates, Change Orders, other document revisions which occurred after the award of the Contract and/or the start of construction activities
      h. System component labels (including outlet numbers) and identifiers for all major components
      i. Shop Drawings, including those submitted for approval and those used for construction but not required for submission.
   2. Notations shall be in a neat, legible and logical manner. Areas affected by the change shall be clouded.

C. Record Documents shall:
   1. Be kept current (i.e. no more than one week behind actual construction) throughout the course of construction.
   2. Be retained at the job site until Final Acceptance.
   3. Be made readily available at all times to the Owner's representative.
   4. Not be the Contractor's working documents.
   5. Be protected from deterioration and loss in a secure, fire-resistive location.
   6. Be made readily available to the Engineer for review of completeness and accuracy throughout the course of construction.
   7. At project closeout, be updated with the items on the Known Exceptions/Deviations List per the requirements of *Part 3 – Execution: Project Close-Out*, herein. Include only those items marked "Approved" by the Engineer.

D. Submission:
   1. Handwritten notations on Record Drawings shall be CAD drafted by the Contractor for preparation of electronic Record Drawings prior to submission. Electronic Record Drawings shall be provided in form, format, size, and 2D or 3D CAD application and version identical to that used by Engineer in preparation of the Construction Drawings (the Construction Drawings set the standard). Electronic Record Drawings that do not meet this standard shall be rejected without review. Unless otherwise indicated, Contractor shall obtain electronic Construction Drawings CAD files from Engineer. Unless otherwise indicated, handwritten notations on Record Drawings and electronic Record Drawings shall be submitted to Engineer during Project Close-Out site visit.

2. Unless otherwise indicated, handwritten notations on Record Drawings shall be submitted to Engineer during Project Close-Out site visit.
3. The Record Drawings shall be reviewed by the Contractor for accuracy and completeness prior to submission.

E. Owner Specific:
1. Submit other information as required by Owner Specific Governing Requirements.

F. Submit additional information as called for in the individual Specification Sections.

1.13 OPERATING AND MAINTENANCE (O&M) MANUALS

A. General:
1. O&M Manuals shall be submitted in accordance with the applicable portions of Division 1.
2. O&M Manuals shall be submitted as a single package and shall include subcontractor and vendor O&M information.
3. O&M Manuals shall be prepared by personnel who are:
   a. Completely familiar with the requirements of this Section
   b. Trained and experienced in the maintenance and operation of the described products
   c. Skilled as a technical writer to the extent required to communicate essential data
   d. Skilled as a draftsperson competent to prepare the necessary Drawings
4. Catalog pages and data included in O&M Manuals shall be originals. Where not possible to obtain original copies in sufficient quantity, catalog pages and data shall be neat, clean copies of the originals.
5. O&M Manuals shall include the following:
   a. Table of Contents
   b. Operations: Assemble operations and instructions data which shall include all procedures necessary for activating and controlling each system and/or component in all modes of operation and for fulfilling all functional requirements.
   c. Product Data: Include the product data provided in the original Submittal(s) reflecting product as supplied and installed, as well as additional information such as manufacturer, installation, operation, routine maintenance information, and technical specifications.
   d. Shop Drawings: Include the Shop Drawings provided in the original Submittal(s) reflecting the system and/or components as installed.
   e. Service Information: Assemble service information (cleaning, adjustments, frequency, etc.) for each device requiring service. For devices requiring qualified service, compile an index of qualified service providers (and their contact information) able to service these devices. Provide a recommended maintenance schedule for each device.
   f. Spare Parts: Assemble a list of spare parts. Compile an index of spare parts providers (and their contact information) able to provide the spare parts.
   g. Tests Results: Assemble all test documentation made for each system, device, and/or component requiring testing.
   h. Calibration/Configuration Settings: Assemble and document all calibration/configuration settings made for each system, device and/or component requiring calibration and/or configuration. Include 'normal' settings for each component.

i. Record Documents: Provide Record Documents per the requirements of *Part 1 – General: Record Documents* herein.

j. Final punchlist: Provide the final punchlist including all corrective action taken and Contractor initials per the requirements of *Part 3 – Execution: Project Close-Out*.

k. Certificates of Inspection: Provide certificates of inspection and final approval from all applicable Governing Authorities, the Manufacturer(s), the Contractor's RCDD, etc.

l. Warranty: Provide warranty documentation per the requirements of Division 27 Specification Section *Warranty* and the individual Specification Sections.

m. Software, including but not limited to:
   1) All source code for custom programs. Source code shall be provided on CD-ROM.
   2) System software
   3) Computer system operating software
   4) Application software
   5) Version Documentation: Provide a spreadsheet in MS Excel format documenting all software and firmware versions for all programmable devices. Provide in both printed format and on CD-ROM.

n. Other Information:
   1) Submit additional information as called for in the individual Specification Sections.
   2) Owner Specific: Submit other information as required by Owner Specific Governing Requirements.

6. O&M Manual contents shall also be submitted in both hard copy and soft copy on CD-ROM.

B. O&M Manual format:
1. O&M Manuals shall be bound in one letter-sized (8-1/2 inch by 11 inch) hard cover (hard back or loose leaf) binder.
2. Separate O&M Manuals shall be provided for each Communication System (i.e. Communications Cabling, Audiovisual, Security, etc.)
3. Front cover of the O&M Manual shall indicate the name of the project, the project number, the name of the Owner, the title of the O&M Manual indicating the communications system (Communications Cabling System O&M Manual, Audiovisual System O&M Manual, Security System O&M Manual, etc.), the year of completion, the name of the Engineer, the name of the Contractor, and as applicable the names of the Architect and the General Contractor.
4. Side cover of the O&M Manual shall indicate the name of the project, the project number, the name of the Owner, and the title of the O&M Manual.
5. O&M Manual shall include each section defined under *O&M Manual Requirements* above.
6. O&M Manuals shall include tab dividers, titled (not numbered) for each section. Tab dividers shall not be handwritten.
7. O&M Manuals shall include a table of contents identifying sections and page numbers.
8. Pages within each section shall be numbered.
9. Drawings (excluding full size Record Drawings) shall be bound and accordion folded to 8-1/2 inch by 11 inch size.

C. O&M Manual submission:
   1. The Contractor shall submit one draft copy of the O&M Manual for review and approval by the Engineer.
      a. The submission will be reviewed for accuracy, completeness, and compliance to the requirements herein. A submission which fails to meet these requirements will be rejected and returned to the Contractor together with review comments and specific actions to be taken by the Contractor. The Contractor shall revise the O&M Manual and re-submit for review and approval.
      b. The O&M Manual shall continue to be re-submitted and reviewed until such time as the O&M Manual is approved by the Engineer.
      c. The Contractor shall be responsible for fees incurred by the Engineer resulting from subsequent review of O&M Manuals that fail to meet the requirements herein. Such fees will be incurred after the Engineer has reviewed the original submission and one re-submission.
   2. Upon approval of the draft copy, the Contractor shall submit final copies in quantities per the requirements of Division 1.

D. Final payment to the Contractor will not be authorized until the final copies of the O&M Manuals (including Record Documents) have been received and approved by the Engineer.

PART 2 - MATERIALS

2.1 GENERAL

A. Part Numbers: Refer to the equipment schedule(s) on the Technology Construction Drawings for specific manufacturers and part numbers. If no part number is provided, then any part meeting the manufacturer and requirements specified is acceptable.

B. Where one or more products are listed for a specified component:
   1. The product listed first shall establish size, capacity, grade, quality, technical specifications, and the basis of design.
   2. Products not listed first shall be considered “other acceptable” products. Should the Contractor choose to use those products, costs for changes to the construction required to support the use of these products shall be borne by the Contractor.

C. If no product is listed, then any manufacturer able to meet the listed Specifications is acceptable.

D. The Contractor is responsible for providing submittals for product as indicated and shall comply with the requirements of *Part 1 – Submittals* herein. Substitutions shall comply with the requirements of *Part 1 – General: Substitutions and Deviations* herein.

E. Unless otherwise indicated, where product is specified without the statement “or equal”, substitutions will not be considered.

2.2 MATERIALS

A. The Contractor is responsible for providing all incidental and/or miscellaneous tools, scaffolding, consumable items, testing equipment appliances, and other hardware not explicitly specified or shown on the Drawings required for the installation of a complete and operable systems ready for the Owner's use.

B. Products shall be:
   1. New and unused, free from blemish and defects.
   2. Standard products of manufacturers regularly engaged in the production of such products.
   3. Of the manufacturers latest standard design at the time of procurement,
   4. Designed to ensure satisfactory operation and life in the environmental conditions that prevail in their installation location.
   5. Designed for application in commercial/professional systems, except as otherwise specifically noted.

C. All products, whether stock or custom, shall be supported by replacement parts and manufacturer schematic drawings as applicable. "Black box" and/or unidentified components are not acceptable.

D. All products of the same or similar type shall be the product of one manufacturer.

E. All component products within a unified system shall be the product of one manufacturer.

F. Equipment shall be UL listed, or equivalent.

2.3 DELIVERY, STORAGE, AND HANDLING

A. Prior to ordering and delivery of equipment, the Contractor shall:
   1. Verify that the equipment shall adequately pass through building openings and passageways with unobstructed access to the final equipment location. When building openings and passageways will not permit the equipment to pass through unobstructed, equipment shall be manufactured and shipped in sections for final assembly at the equipment location.
   2. Verify that the equipment shall properly fit the space allocated, that required clearances can be maintained, and that the equipment can be located without interference from other systems, structural elements, or the work of other trades.

B. The Contractor shall arrange deliveries in accordance with the construction schedule. Deliveries shall be scheduled to maintain the progress of work, to avoid conflict with the work of other Trades, and to accommodate site conditions.
   1. The Contractor shall be responsible for coordinating and scheduling the timely delivery of products and materials indicated to be furnished by others or by the Owner.

C. Deliver, store and handle products and materials in full compliance with the manufacturer's recommendations and/or instructions, using means and methods that will prevent damage, deterioration, and loss (including theft).

D. The Contractor shall protect products and materials until Final Acceptance. Such protection is the sole responsibility of the Contractor, and the Contractor shall be responsible for replacing damaged, deteriorated, stolen or lost product at no additional cost to the Owner.
   1. Where products and materials are indicated to be furnished by others or by the Owner, the Contractor shall make a complete and careful check of all materials delivered. The Contractor shall provide a written and signed receipt acknowledging acceptance of the delivery and the condition of the materials delivered. After receipt, the Contractor shall assume full responsibility for the materials.

E. Products and materials subject to damage by the elements shall be stored above ground, under cover, in a weather tight enclosure, with ventilation adequate to prevent condensation. Temperature and humidity shall be maintained within the manufacturer's recommendations.

F. The Contractor shall make provisions for receiving and storing products and materials, including products and materials to be furnished by the Owner (or by others) to be installed by the Contractor as part of the work.

G. Products and materials shall be carefully inspected for damage upon delivery. Defective or damaged products and materials shall be marked 'Rejected', removed from the site, and shall not be installed.

H. Products and materials shall be delivered to the site in the manufacturer's original containers, complete with labels and instructions for the proper handling, storage, unpacking, protection and installation.

I. The Contractor shall ensure that products and materials to be installed are not temporarily used as steps, ladders, platforms, scaffolds, or for storage by the Contractor or by other trades during the construction process. Materials found to be used in such a manner will be considered "damaged", shall not be installed, and shall be replaced at no additional cost to the Owner.

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the latest edition of applicable portions of the Governing Requirements in effect at the time of construction, including all addenda, errata, annexes, and technical service bulletins (TSBs), etc., except where a specific edition is otherwise indicated, or where otherwise mandated by a Governing Authority. Where the specific edition is indicated for a Governing Requirement that is not mandated by a Governing Authority, and a later edition is available for such Governing Requirement at the time of construction, the more stringent applicable provisions of both the latest and specifically indicated editions of such Governing Requirement shall prevail.

B. In the event of a conflict between a code and the other Governing Requirements, or between a code and a requirement of the Construction Documents, the code requirement shall govern. However, if the non-code requirement (or portion thereof) exceeds that of the code, and is furthermore not contrary to the code, the non-code requirement (or portion thereof) shall prevail.

C. Installation shall be performed by workers skilled in the trade, familiar with the particular techniques and methods of construction applicable to the work of the trade.

D. Completed work shall present a neat and professionally installed appearance. The appearance of the work shall be of equal importance to its operation. Failure to present a neat and professionally installed appearance shall be considered sufficient reason for rejection of the system in part or in whole.

E. Completed work shall demonstrate quality workmanship. Quality workmanship shall be of equal importance to its operation. Failure to demonstrate quality workmanship shall be considered sufficient reason for rejection of the system in part or in whole.

F. In the event that supplemental information is required to confirm the intent of the Construction Documents, the Contractor shall notify the Engineer and await the Engineer's response prior to procurement of materials and performance of the related work. Procurement of materials and work performed without such interpretation and/or clarification is at the sole risk of the Contractor, and as such, the Contractor shall correct such work at no additional cost to the Owner should the materials or work not conform to the intent of the Construction Documents.

G. The Contractor shall order and install materials and equipment with long lead times and/or those having a major impact on work by other trades so as not to jeopardize the project or project schedule.

H. The Contractor is responsible for ensuring that each installed component's performance is within the Manufacturer's published specifications, the Governing Requirements, and all other requirements as specified within this Division.

I. The Contractor is solely responsible for the safety of the public and workers in accordance with all applicable rules, regulations, building codes and ordinances, and Governing Requirements, including but not limited to employee training and Safety Program development, documentation and execution.

J. Notwithstanding any other provisions of the Contract Documents, the Contractor shall be solely responsible for location and protecting any and all utility service lines (both Owner controlled and Public) in the work area.

3.2 SUPERVISION

A. The Contractor shall appoint a Project Manager who will be the single point of contact for all work accomplished under this Project and will be vested by the Contractor with the authority to make decisions on behalf of the Contractor.
   1. The Project Manager will be responsible to represent the Contractor and coordinate all aspects of this Project, including but not limited to:
      a. Overall and specific project responsibility
      b. Thorough knowledge of Project Specifications and Drawings
      c. Creation and maintenance of a project schedule, including milestones, task definitions and resource allocations
      d. Attendance at all Project Management meetings
      e. Supervision and direction of all Contractor personnel
      f. Documentation, including submittals and change orders

g. Quality assurance of Project

2. The Project Manager initially assigned to the Project shall be assigned to the Project for the duration of the Project. Once assigned by the Contractor, the Project Manager shall not be changed by the Contractor without Engineer and Owner approval.

B. The Contractor shall assign a qualified Foreman to the Project and shall keep the Foreman on site and in charge of the work at all times. The Foreman shall be equipped with a mobile phone during project working hours.

1. The Foreman initially assigned to the Project shall be assigned to the Project for the duration of the Project. Once assigned by the Contractor, the Foreman shall not be changed by the Contractor without Engineer and Owner approval.

3.3 PERMITS AND FEES

A. The Contractor shall make arrangements to obtain and pay for necessary permits, licenses, and inspections.

B. No work shall be started prior to obtaining necessary permits and payment of required fees. Work installed prior to obtaining proper permits shall, if required by the Governing Authority (AHJ), be redone in compliance with requirements at no additional cost to the Owner.

3.4 INSTALLATION

A. The Contractor shall notify the Engineer and wait for direction/instruction prior to proceeding with procurement and installation for any portion of the Work which could be affected by the following:

1. Required items and/or details have been omitted from the Construction Documents.
2. Discrepancies or conflicts exist between the requirements of the Drawings and the Specifications, between the Governing Requirements and the Construction Documents, and/or between the various Governing Requirements.
3. Discrepancies or conflicts between the requirements of this Division and those of Division 1.

B. Dimensions and clearances:

1. Equipment dimensions and dimensions indicated for the installation of equipment are restrictive dimensions. Verify that the equipment will fit within the indicated locations and spaces.
2. Maintain, at a minimum, code required clearances.
3. Promptly notify the Engineer of any potential dimension or clearance conflicts, and await the Engineer's direction prior to purchase and rough-in of the equipment.

C. Access:

1. Install equipment such that it is readily accessible for operation and maintenance.
2. Access to equipment shall not be blocked or concealed by conduits, supporting devices, boxes, or other items.
3. Do not install equipment such that it interferes with the normal operation or maintenance requirements of other equipment.

D. Equipment shall be installed level, plumb, parallel, and perpendicular to building structures and to other building systems and components, except where otherwise indicated.

E. Seismic Bracing: Equipment shall be seismically braced as required by the governing requirements. Bracing shall be rigid – non-rigid bracing (chains, cables, etc.) is not acceptable, unless otherwise recommended by the manufacturer and approved or specified by the governing requirements. Seismic bracing hardware shall be provided by the manufacturer, or shall be approved or recommended by the manufacturer. Where no manufacturer hardware, approval, or recommendation is available, the seismic assembly shall be approved by a licensed structural engineer.

F. Equipment shall be securely fastened. Select fasteners so that the load applied to any one fastener does not exceed 25 percent of the proof-test load.

G. Place equipment labels and/or other identification where the label and/or identification can be easily seen and read without difficulty.

H. Grounding/Bonding: Bond all non-current carrying raceway to the nearest TGB.

I. Attachment of hanger rods, support cables, diagonal wall bracing, and any other connections made to the building structure after the application of fireproofing/firestopping materials, shall be made with minimal impact to the fireproofing/firestopping materials. The Contractor making such connections shall remove only as much fireproofing/firestopping as required for the attachment, and for scoring and over-cut only as required for the connection. The Contractor shall be held responsible for costs associated with patching of excessively removed fireproofing/firestopping material.

J. Cables, conduits, and other raceway shall be firmly secured and cleaned where penetrating fire rated barriers.

3.5 DRAWINGS

A. Drawings shall not be scaled for rough-in measurements or equipment locations. Field verification of dimensions, locations, and levels to suit field conditions is required. Final placement of devices, outlets, equipment, etc. shall be coordinated with field conditions.

B. Unless specifically dimensioned or detailed, Drawings indicate approximate locations, arrangement, and general character. To avoid interference with structural members and equipment of other trades, or for the convenience of the Owner, it may be necessary to adjust the locations shown on the Drawings prior to installation. Unless specifically dimensioned or detailed, and with the exception of locations of equipment and raceway in specialized communications rooms and spaces (such as Telecommunications Rooms, Data Centers, etc.), the Contractor may make minor location adjustments without obtaining the Engineer's prior approval. All other adjustments require prior approval from the Engineer.
   1. Minor adjustments are defined as distances not to exceed:
      a. 1 foot at grade, floor ceiling, and roof level in any direction in the horizontal plane
      b. 1 foot on walls in a horizontal direction within the vertical plane.

2. Particular attention shall be paid to door swings, piping, ductwork, structural steel, and other ceiling conflicts:
   a. In general, waste and vent lines, large pipe mains, and ductwork shall be given priority for the locations and spaces shown.
   b. In general, electrical lighting fixtures shall be given priority for ceiling space.
3. Where minor location adjustments are required, such adjustments shall be made at no additional cost to the Owner.

3.6 ASBESTOS, LEAD, OR OTHER HAZARDOUS MATERIALS

A. In the event the Contractor encounters suspected asbestos, lead, or other hazardous materials, the Contractor shall immediately stop work in the area affected and report the condition to the Owner verbally followed by written notice. Work in the affected area shall not be resumed except by written agreement between the Owner and the Contractor.

3.7 RESTORATION

A. The Contractor shall restore all floors, ceilings, walls, furniture, grounds, pavement, etc. affected or damaged by the Contractor's work. All such areas shall be restored to original condition at no additional cost to the Owner.

B. The Contractor shall restore to original finish all new products, materials, and equipment scratched, chipped, or otherwise marred by the Contractor.

C. Restoration in every instance consists of completing the work to match and blend with the adjoining existing work insofar as methods, materials, colors, and workmanship are concerned.

D. Restoration work shall be performed by workers qualified and skilled in the trades involved.

E. Where restoration work requires painting: Painting shall consist of cleaning, surface preparation, painting (primer, intermediate, and finish) and finishing surfaces, for items both new and existing, affected by the work of the Contractor. Surface painting shall match and blend with existing adjoining surfaces. The areas around penetrations, once sealed, shall be painted.

F. The Contractor shall be responsible for replacing improperly matched, blended, or poorly constructed restorative work at no additional cost to the Owner.

3.8 HOUSEKEEPING

A. During the course of construction:
   1. The Contractor shall keep the building, premises and surrounding area free from accumulated surplus, waste materials and rubbish at all times.
   2. At the conclusion of each work shift, remove empty boxes, crates, surplus and waste materials, and other debris, and sweep clean all work areas affected by the Contractor's work.

3. In occupied areas affected by the Contractor's work, the Contractor shall remove all evidence of the Contractor's work in those areas at the end of each work shift, including tools, equipment and scaffolding, leaving the area clean, unobstructed and fully useable by the occupants.

B. At project completion, and prior to Final Acceptance:
1. Remove all tools, equipment and scaffolding.
2. Remove temporary labels and adhesives.
3. Thoroughly vacuum the interior of enclosures to remove debris.
4. Clear surplus product, materials and debris from the job site.
5. Turn over equipment to the Owner in unblemished condition.
6. Thoroughly clean equipment and facilities inside and out, and remove all residue -- all areas affected by the Work shall cleaned.
7. Turn over the Work to the Owner in a fully operational state.

C. All final cleanup work shall be performed by professional cleaners qualified and skilled in the trade. The Contractor shall not make use of unqualified personnel for cleanup work.

D. The Project shall not be considered complete until all area affected by the Work are left in a clean, neat, orderly, and fully operable condition.

3.9 SUBSTANTIAL COMPLETION

A. Due to the technical nature of the Work, as well as the requirement that certain Owner provided equipment, systems, and training may necessitate use of the Work by the Owner prior to Substantial Completion, the Owner reserves the right to use the Work prior to Substantial Completion (when ready for use) without obligation to the Contractor and without implying Acceptance of the Work.

B. Pre-Substantial Completion Submittal: Three weeks prior to Substantial Completion, the Contractor shall prepare and submit the following:
1. Known Exceptions/Deviations List:
   a. The Contractor shall compile a thorough list of known exceptions/deviations (in materials, construction, and/or workmanship) from that specified in the Contract Documents, and for which there was not associated documentation in the form of Change Orders (CO), Construction Change Directives (CCD), Architects Supplemental Instructions (ASI), or responses to a Request for Information (RFI).
   b. The Contractor shall submit the list to the Engineer for review. The Engineer shall review each item and mark as either Accepted or Not Approved.
      1) Items marked "Not Approved" shall be corrected by the Contractor to conform with the intent of the Contract Documents at no additional cost to the Owner.
      2) The Contractor shall perform corrective action for "Not Approved" items prior to notifying the Engineer that the work is Substantially Complete.
2. Other information as called for in the individual Specification Sections.
3. Owner Specific: Submit other information as required by Owner Specific Governing Requirements.

C. Notice of Substantial Completion: When the Work nears Substantial Completion, the Contractor shall notify the Engineer in writing the date that the work will be Substantially Complete and ready for review by the Engineer.

3.10 PROJECT CLOSE-OUT

A. Punchlist:
   1. Once notice of Substantial Completion is received, the Engineer shall visit the site to review the Work, and shall prepare a punchlist of items determined to be incomplete, deficient or otherwise not in compliance with the intent of the Contract Documents.
      a. During the review of the Work, if the Engineer finds that the Known Exceptions/Deviations List provided by the Contractor was insufficiently thorough, that the Work is not Substantially Complete, or that deficiencies in the work are excessive, the Engineer will cease review and inform the Contractor that the work is not Substantially Complete. The Contractor shall be responsible for fees incurred by the Engineer for this partial review.
   2. The Contractor shall perform corrective action for each item noted in the punchlist. When complete, the Contractor shall submit the original punchlist with each item initialed attesting to the fact that the item was corrected.
      a. If necessary, the Engineer will perform a subsequent review after receipt of the Contractor initialed punchlist.
   3. Should additional reviews beyond the original punchlist review be required of the Engineer due to the Contractor's failure to correct all incomplete, deficient, or non-compliant work, the Contractor shall be responsible for fees incurred by the Engineer for the additional reviews.

B. Acceptance Testing
   1. Once the punch list items have been corrected, the Engineer shall visit the site to review the fully functioning and operating system and shall prepare an acceptance testing punchlist of items determined to be incomplete, deficient or otherwise not in compliance with the intent of the Contract Documents.
      a. During the review, the Engineer finds that the Known Exceptions/Deviations List provided by the Contractor was insufficiently thorough, that the Work is not Substantially Complete, or that deficiencies in the work are excessive, the Engineer will cease review and inform the Contractor that the work is not Substantially Complete. The Contractor shall be responsible for fees incurred by the Engineer for this partial review.
   2. The Contractor shall perform corrective action for each item noted in the acceptance testing punchlist. When complete, the Contractor shall submit the original acceptance testing punchlist with each item initialed attesting to the fact that the item was corrected.
      a. If necessary, the Engineer will perform a subsequent review after receipt of the Contractor initialed acceptance testing punchlist.
   3. Should additional reviews beyond the original acceptance testing punchlist review be required of the Engineer due to the Contractor's failure to correct all incomplete, deficient, or non-compliant work, the Contractor shall be responsible for fees incurred by the Engineer for the additional reviews.

C. Provide O&M Manuals per the requirements of *Part 1 – General: Operating & Maintenance (O&M) Manuals* herein.

END OF SECTION 270010

SECTION 270020 - CONTRACTOR QUALIFICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section defines Contractor qualifications and requirements for bidding the various systems in this Division.

1.2 QUALIFICATIONS FOR BIDDING

A. Contractors shall be qualified to bid per the requirements of *Part 1 – General: Contractor Qualifications* herein. Qualification criteria shall be satisfied prior to the date of Bid.

B. Pre-qualified Contractors:
   1. The following Contractors have met the qualification requirements and are pre-approved (by system type) to bid the Work:
      a. Communications Cabling System (Data Cable Terminations):
         1) Interface Communications Co. (Shawn Ludwig, 720-470-2145)
         2) Sturgeon (Jeff Bunker, 303-286-8000, 720-281-2363 Cell)
         3) Wire to Wire (Phil Ames, 303-576-6668, 303-618-3186 Cell)
      b. Communication Cabling System (Fiber Terminations)
         1) Backbone Fiber Systems (Solomon Howes, 970-667-0014, 970-215-6433 Cell)
         2) Sturgeon (Todd Frank, 303-286-8000, 303-227-7005 Direct)
      c. Security System(s):
         1) Dictoguard (Jeff Goodman, 970-356-5612)
      d. Electrical For Communications Systems:
         1) Refer to Division 26 for Electrical Contractor requirements.
   2. Contractors not listed above must be pre-approved to submit a bid:
      a. In order to obtain approval for bidding, Contractors shall submit their Statement of Qualifications (see *Part 1 – General, Statement of Qualifications* herein) to the Engineer at least two weeks prior to the bid date.
      b. Upon review, the Engineer will return a written statement to the Contractor stating that the Statement of Qualifications was either "Accepted" or "Rejected". If "Accepted" this statement shall serve as the Contractor's 'Engineer's Statement of Approval to Bid.'
      c. If pre-approved to bid, the Contractor shall submit a bid together with the 'Engineer's Statement of Approval to Bid.' Bids submitted without the Engineer's written statement of pre-approval will be rejected without review.

1.3 CONTRACTOR QUALIFICATIONS

A. General

1. Experience:

a. Governing Requirements: The Contractor shall have demonstrated, in-depth and working knowledge of the applicable portions of the Governing Requirements as noted in Division 27 Specification Section *Basic Communications Requirements* and as they pertain to the systems to be installed by the Contractor. The Contractor shall provide a signed statement stating same.

b. Design and Installation Practices: The Contractor shall have demonstrated, in-depth and working knowledge of the generally accepted design and installation practices for the systems to be installed by the Contractor. The Contractor shall provide a signed statement stating same.

c. Contractor References:

1) Project: The Contractor shall provide references for no less than five similar projects (in terms of size and construction cost) performed by the Contractor within the past three years.

a) The reference list shall detail, for each project:

i. Project name and location

ii. Construction cost

iii. A brief description of the project and the components involved

iv. Contact names, phone numbers, and addresses

v. Date completed

b) A minimum of two of the references shall be in the vicinity of the Project and shall be available for the Owner and Engineer to visit and inspect the installation. The Contractor shall highlight or otherwise make note of these particular references.

2) Service Department: The Contractor shall provide a minimum of two references for the Contractor's Service Department. A minimum of one of the references shall be in the vicinity of the Project.

2. Manufacturer(s) Certification:

a. The Contractor shall be trained and certified by the Manufacturer(s) to install, test, and maintain the major components of the system, shall be certified to perform service and equipment modifications without voiding the Manufacturer(s) warranty, and shall be certified by the Manufacturer(s) to provide these services in the location in which the Work is to be performed. The Contractor shall provide evidence of same for each major component Manufacturer – statements on letterheads from distributor, importer or local sales representatives are not be acceptable.

3. Offices:

a. Locations: Provide locations of all regularly/fully staffed and operational offices and the number of administrative staff and technical personnel in each. Indicate which office(s) have a Service Department, and of those offices, indicate the number and type of personnel staffing the Service Department.

b. Service Department: The Contractor shall maintain a permanently staffed and equipped Service Department, regularly providing services for the systems to be installed by the Contractor. The Contractor shall provide a signed statement stating same.

c. The Contractor shall be licensed, bonded, and insured in the State in which the Work is to be performed. The Contractor shall provide evidence of same.

d. If required by the locality, the Contractor shall be licensed by the locality. The Contractor shall provide evidence of same.

4. Personnel:

a. Project Manager: The Contractor's Project Manager assigned to this project shall have a minimum of three years continuous contracting project management experience on projects of similar size and complexity. The Project Manager shall have the authority to act for the Contractor, shall serve as the technical liaison between the Contractor and the Engineer, shall represent the Contractor at all meetings, shall be responsible for supervision of all work required to execute the Contract, shall review and approve all submittals prior to submission, and shall be present at the job site during final inspection. The Contractor shall provide a resume for the Project Manager which shall include:

1) A summary of the Project Manager's experience, including education, with emphasis on key skills relating to project management and the technical aspects of the systems for which the Project Manager will have responsibility.

2) A listing of continuous projects (with dates) over the past three years on which the Project Manager performed project management duties. Project information shall include:

a) Project name and location
b) Construction cost
c) A brief description of the project and the components involved
d) Contact names, phone numbers, and addresses
e) Date completed

b. Foreman: The Contractor's Foreman assigned to this project shall have a minimum of three years continuous supervision experience on projects of similar size and complexity. The Contractor shall provide a resume for the Foreman which shall include:

1) A summary of the Foreman's experience, including education, with emphasis on key skills relating to installation supervision and the technical aspects of the systems for which the Project Foreman will have responsibility.

2) A listing of continuous projects (with dates) over the past three years on which the Foreman performed supervisory duties. Project information shall include:

a) Project name and location
b) Construction cost
c) A brief description of the project and the components involved
d) Contact names, phone numbers, and addresses
e) Date completed

c. Employee Certification: Contractor personnel directly involved with the supervision, installation, testing, and certification of the system shall be trained and certified by the major component Manufacturer(s). The Contractor shall provide evidence of same.

B. Systems Specific Qualifications: Additional Contractor Qualifications are required for each system as follows:

1. Communications Cabling System:

a. The Contractor shall be completely familiar with and have extensive working knowledge of the TIA standards for telecommunications systems, the design and installation practices as defined in the BICSI Telecommunications Distribution Methods Manual, and the installation practices as defined in the BICSI Telecommunications Cabling Installation Manual. The Contractor shall provide a signed statement stating same.

b. RCDD: The Contractor shall assign an RCDD (Registered Communications Distribution Designer) to the project. The RCDD shall be a permanent member of the Contractor's staff (i.e. an RCDD consultant/sub-contractor to the Contractor is not acceptable) and shall be in current good standing with BICSI. The Contractor shall provide the name of and evidence of certification for the Contractor's RCDD to be assigned to the project.

c. Manufacturer Certification: The Contractor shall be trained and certified by the specified communications cabling system Manufacturer to install, test, and maintain the communications cabling system, shall be certified by the Manufacturer to provide the Manufacturer's most comprehensive performance and product warranty per the requirements of Division 27 Specification Section *Warranty* and it's related sub-sections, and shall be certified by the Manufacturer to provide this warranty in the location in which the work is to be performed. The Contractor shall provide evidence of same.

1) The Contractor shall be Manufacturer Certified as one or more of the following:

a) Belden/CDT Certified System Vendor (CSV).

b) CommScope SYSTIMAX Premier Business Partner.

c) Corning Extended Warranty Program (EWP) Certified Installer.

d) Panduit Certified Installer registered by Panduit to provide and Warranty the Panduit Cable "PanGen / PanPan" Structured Cabling Solution.

d. Employee Certification: Contractor personnel shall be trained and certified by the Manufacturer as follows. The Contractor shall provide evidence of same:

1) Project Foreman and Supervisors: All (100 percent) shall be trained/certified by the Manufacturer for design, installation and testing.

2) Technicians (responsible for testing, termination, connectorization, and determination of pathway/routing, and technical labor): All (100 percent) shall be trained/certified by the Manufacturer for installation and testing.

3) Installers (responsible for cable installation, non-technical labor, etc.): Not required (subject to the requirements of the Manufacturer's warranty and that of the next paragraph). However, these technicians must be directly supervised by a certified Installation Technician in an on site ratio of not less than one Manufacturer certified Installation Technician per two non-certified installers.

4) Overall, at least 30 percent of installation personnel shall be BICSI Registered Telecommunications Installers or have an equivalent Manufacturer's certification. Of that number, at least 15 percent shall be registered at the Technician's Level, at least 40 percent shall be registered at the Installer Level 2, and the balance shall be registered at the Installer Level 1.

5) Other personnel: Personnel not directly responsible for installation supervision, installation, testing or certifying the communications cabling system (i.e. project managers, cleanup crew, etc.) are not required to be manufacturer trained and certified.

2. Security System(s):
   a. Programmer Certification: The Contractor shall have Manufacturer certified programmers for all equipment requiring programming. The Contractor shall provide evidence of same.
   b. In-House Capabilities: The Contractor shall have in-house capabilities and facilities for rack assembly, shop fabrication, and programming. The Contractor shall provide a signed statement stating same.
   c. Product Dealer Information: Provide a list of manufacturers/products for which the Contractor is a Dealer. Provide the duration of the relationship and the extent of manufacturer/product training.
3. Electrical For Communications Systems:
   a. Refer to Division 26 for Electrical Contractor requirements.

1.4 STATEMENT OF QUALIFICATIONS (SOQ)

A. The Contractor shall prepare a Statement of Qualifications which shall include all documentation verifying compliance with the requirements of and as called for in *Part 1 – General: Contractor Qualifications* herein. The Statement of Qualifications shall include, at a minimum:
   1. General:
      a. Governing Requirements Statement
      b. Design and Installation Practices Statement
      c. Contractor Project References
      d. Contractor Service Department References
      e. Evidence of Manufacturer(s) Certification
      f. Office locations and information
      g. Service Department Statement
      h. Evidence of licensing, bonding, and insurance
      i. Project Manager Resume
      j. Foreman Resume
      k. Evidence of Manufacturer(s) Training/Certification for those personnel for which training/certification is required.
   2. Systems Specific Statement of Qualifications: There are additional SOQ requirements for each system. The Contractor shall include the following system specific documentation within the Statement of Qualifications specified above:
      a. Communications Cabling System:
         1) TIA Standards and BICSI Practices Statement
         2) Evidence of certification for the Contractor's RCDD assigned to the project
         3) Evidence of Manufacturer(s) Certification and Warranty
         4) A list of personnel to be assigned to the project, the type of work they will be performing, and evidence of Manufacturer(s) Training/Certification for those personnel for which training/certification is required.
      b. Security System(s):
         1) Evidence of Programmer Certification
         2) In-house Capability Statement
         3) Product Dealer Information

c. Electrical For Communications Systems:
1) No additional information is required.

B. A Statement of Qualifications that is incomplete or does not clearly demonstrate that the qualification requirements have been met shall be rejected

1.5 SUBMITTALS

A. Provide the following per the criteria set forth in Submittals in Division 27 Specification Section *Basic Communications Requirements*:
1. Other Information:
a. Provide a Statement of Qualifications for each Contractor and for each system to be provided by the Contractor.

PART 2 - MATERIALS

2.1 THIS SECTION NOT USED

PART 3 - EXECUTION

3.1 THIS SECTION NOT USED

END OF SECTION 270020

SECTION 270030 - BIDDING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section provides requirements for bidding, including a format and definitions for the presentation of pricing for the base bid, and where applicable, alternate bid(s) and unit pricing. The contents of this Section are intended to establish pricing breakdowns which are useful to the Owner and the Engineer for evaluating bid responses.

B. Information as called for in this Section shall be provided per the requirements of the General Provisions of the Contract, Bidding Documents, Contract Forms, General Conditions, and the Construction Documents.

1.2 BASIS OF BID

A. The Contractor shall determine all existing conditions affecting the work, the type of construction to be used, and the nature and extent of work provided by other trades. Failure to do so shall be construed as willingness to provide complete and fully operational system(s) within the amount bid by the Contractor.

B. The Contractor shall notify the Engineer a minimum of ten (10) days prior to the bid date in the event of any of the following circumstances:
   1. Required items or details have been omitted from the Construction Documents
   2. Discrepancies or conflicts between the requirements of the Drawings and the Specifications, between the Governing Requirements and the Construction Documents, and between the various Governing Requirements.
   3. Discrepancies or conflicts between the requirements of this Division (27) and those of Division 0 or Division 1.

C. Where omissions, discrepancies, or conflicts are not brought to the attention of the Engineer, it shall be assumed that the most stringent requirement(s) constitute the basis for the Contractor's bid, and as such shall be construed as willingness by the Contractor to provide complete and fully operational system(s) within the amount bid.

D. Fees for necessary or required licenses, permits, and inspections shall be included in the bid amount.

E. Bids shall be based on products, materials and methods of construction as specified. Bids based upon substitution of product and materials, as well as deviations from the methods of construction specified, shall be at the sole risk of the Contractor and as such are subject to rejection without consideration at the time of submittal review – should the Contractor be awarded the contract.

F. If the bidder proposes to sub-contract portions of the work, sub-contractors shall be identified and their Statement of Qualifications (per Division 27 Specification Section *Contractor Qualifications*) submitted as part of the Bidder's bid submission.
   1. The Contractor is responsible for any and all work performed by a sub-contractor, and shall provide direct and continuous supervision of the sub-contracted work. Furthermore, this clause applies to any work provided by the Manufacturer(s) for equipment installation at the Contractor's request.

G. By submitting a Bid, the Contractor agrees:
   1. To honor the Contractor's Bid for 90 days subsequent to the date that bids are opened.
   2. To enter into and execute a Contract, if awarded, and to furnish all bonds and insurance required by the Contract Documents.
   3. To accomplish the Work in accordance with the Contract Documents.
   4. To complete the Work within the schedule stipulated by the Contract.
   5. That the Owner reserves the right to:
      a. Adopt all or any part of the Bidder's proposal.
      b. Reject any or all bids received.
      c. Withhold the award of the Contract or otherwise choose to not award the Contract.
      d. Waive or decline to waive any informality or irregularities in any bid response received.
      e. Select the Bidder the Owner deems to be most qualified to fulfill the needs of the Project. The lowest cost proposal will not necessarily be the proposal deemed to be the most qualified – factors in addition to cost will be used to determine the most qualified proposal.

1.3 BID FORMAT

A. The Bid shall contain the following mandatory documentation. Bids submitted without this documentation (in whole or in part) may be rejected without review. The documentation shall be provided in addition to any forms/documents required by the General Provisions of the Contract and/or the contracting authority.
   1. Statement of Qualifications: Provide per Division 27 Specification Section *Contractor Qualifications* and/or its sub-sections.
   2. Bid Form: A bid form summarizing the Contractor's bid as required by the General Provisions of the Contract and/or the Contracting Authority.
   3. Bid Supplement: Complete the Bid Supplement attached to the end of this Section.
      a. The Bid Supplement shall be completed in addition to any forms/documentation required by the General Provisions of the Contract and/or the contracting authority.
   4. **Additional Information:**
      a. Subcontractor Identification: Identify sub-contractors and their responsibilities. Submit their Statement of Qualifications per Division 27 Specification Section *Contractor Qualifications* and/or its sub-sections.
      b. Bill of Materials (BOM): The BOM shall include each item individually priced, and shall reflect any and all required modifications, accessories, and labor for the item. Each item listed shall be complete with the following information:
         1) Description
         2) Part number (if applicable)
         3) Quantity included in bid
         4) Material cost (including all required modifications, accessories and incidental materials)

5) Labor cost to install (if applicable)
6) Total installed price

c. Bid Bond: Provide documentation/certificate verifying same
d. Performance Bond: Provide documentation/certificate verifying same
e. Pre-Approval Statement: Provide the Engineer's written statement of pre-approval to bid the work per Division 27 Specification Section *Contractor Qualifications* and/or its sub-sections.

1.4 BID SUBMITTAL

A. For Contractor's bidding the Communications Cabling System: If the Contractor is certified with more than one of the approved cabling system Manufacturers, the Contractor shall submit a separate bid for each manufacturer, provided the Contractor fully complies with all requirements of Division 27 Section *Contractor Qualifications – Communications Systems* and Division 27 Section *Warranty – Communications Systems*.

1.5 ALTERNATE PRICING

A. An Alternate is an amount proposed by the Contractor and stated on the Bid Form for certain work defined in the Construction Documents that may be added to or deducted from the Base Bid amount.
   1. The cost or credit for an alternate is the net addition to or deduction from the Base Bid to incorporate the alternate into the work.
   2. Alternate pricing shall include all costs of related coordination, modification, or adjustment of the work to accommodate and completely integrate the Alternate into the project, and shall include all necessary materials, labor, delivery, insurance, applicable taxes, overhead, markups and profit.

1.6 UNIT PRICING

A. Unit pricing is a price per unit of measurement for materials, equipment and/or labor added to or deducted from the Contract Sum by appropriate modification. Unit pricing is to be provided for common items which may be added or deleted during the course of construction.
   1. It is the intent that components added by unit price during construction shall result in complete and operable components ready for the Owner's use. It is further the intent that components deducted by unit pricing shall not adversely impact the remaining or adjacent work.
   2. Unit prices shall include all costs of related coordination, modification, or adjustment of the Work to accommodate and completely integrate the component into the project, and shall include, but shall not be limited to, all necessary materials, labor, programming, incidentals, delivery, insurance, applicable taxes, overhead, markups and profit.
   3. Unit pricing shall remain in effect until Final Acceptance.

B. Provide unit prices for the addition/deduction of the items specified below. Unit pricing is broken out by the system(s) to which they pertain.
   1. Communications Cabling:
      a. Horizontal Outlet: Cable, faceplate, connectors (station and patch panel), terminations, incidental materials, testing, labeling, etc. for any location (regardless of distance from the Telecommunications Room). Provide pricing by outlet type and port quantities as follows:
         1) Prior to walls covered and ceiling installed:
            a) 2-port
         2) After walls covered and ceiling installed:
            a) 2-port
      b. Wireless Access Enclosure: One enclosure, including and all incidental materials for hanging and support, installed.
   2. Security:
      a. Controlled Door
      b. Monitored Door
   3. Electrical:
      a. Outlet Box and Raceway: One recessed single gang opening, 4-11/16 inch by 4-11/16 inch by 2-1/8 inch deep outlet box at the horizontal outlet location with conduit raceway from the outlet box location to:
         1) Stub to accessible ceiling space
      b. Cable Tray: One foot of cable tray, installed complete with all hanging/mounting hardware, bends, drops, etc. for a complete and functional cable tray system:
         1) 6 inch wide tray

PART 2 - MATERIALS

2.1 THIS SECTION NOT USED

PART 3 - EXECUTION

3.1 THIS SECTION NOT USED

END OF SECTION 270030

SECTION 270040 - WARRANTY

PART 1 - GENERAL

1.1 SUMMARY

A. This Section defines general warranty requirements for the Communications System(s).

1.2 GENERAL

A. Warranty
1. The Contractor shall warrant the Work against all defects in materials, equipment and workmanship in compliance with the applicable requirements of Division 1.
2. Manufacturer Warranties: The Contractor's Warranty shall include all Manufacturer Warranties. The Contractor shall represent and act on the Owner's behalf in any and all Manufacturer warranty/replacement proceedings.
3. Manufacturer Support Contract(s): The Contractor shall provide any manufacturer backed maintenance, warranty and/or technical support contract necessary for the Contractor to configure, operate, service, repair and/or replace any component of the Communication System(s). The contract shall be valid for the duration of the warranty period. The Contractor shall purchase the contract in the Owner's name and provide documentation and renewal information to the Owner at acceptance testing.
4. The Contractor shall comply with the Submittal portions of Division 27 Specification Section *Basic Communications Systems Requirements.*
5. All labor, materials, equipment, and other costs and services necessary for the fulfillment of the Warranty shall be provided at no charge to the Owner.

B. Warranty Period
1. Unless otherwise noted or stated in Division 01 specification, the minimum Warranty Period shall be 1 year or as otherwise called for in the General Provisions of the Contract.
2. The Warranty Period shall commence upon Final Acceptance.
3. Manufacturer Warranties:
a. The Contractor shall honor Manufacturer Warranties for the full term established by the Manufacturer when said term is greater than the Warranty Period.
b. In cases where Manufacturer Warranties are less than the Warranty Period, the Contractor is liable for and shall warrant the Manufacturer's equipment for the entire term of the Warranty Period.
c. Where the Contractor has modified equipment, the Manufacturer's warranty may be voided. In such cases, the Contractor shall warrant the Manufacturer's equipment for a term equivalent to that of the original Manufacturer Warranty term, or for the entire Warranty Period, whichever is greater.

C. Warranty Certificate
1. The Contractor shall provide a written Warranty Certificate on the Contractor's letterhead, signed by the Contractor, with terms and conditions of the Warranty complying with the requirements detailed herein.

2. The Warranty Certificate shall include copies of all Manufacturer Warranties. Manufacturer Warranties shall be activated by the Contractor in the Owner's name.
3. The Warranty Certificate shall be submitted as part of the O&M Manual submission.

D. Warranty Fulfillment
1. The Contractor shall provide a Warranty service visit within 24 hours of notification.
2. Defects shall be remedied within 72 hours of notification.

1.3 SYSTEM SPECIFIC

A. The Contractor shall include the following additional system specific items as part of the Warranty above:
1. Communications Cabling System:
a. Communications Cabling System Manufacturer Warranty: The Contractor shall provide a Communications Cabling System extended product, performance/application, and labor Manufacturer Warranty that shall warrant all passive components used in the communications cabling system. Additionally, this Warranty shall cover all components not manufactured by the Manufacturer but approved by the Manufacturer for use in the Communications Cabling System (i.e. "Manufacturer Approved Alternative Products").
1) The Manufacturer Warranty shall warrant:
a) That the products will be free from manufacturing defects in materials and workmanship.
b) That all cabling products of the installed system shall exceed the specification of TIA 568 performance standards. For copper-based cabling products, the TIA 568 Category rating of the specified system shall be exceeded.
c) That the installation shall exceed TIA 568 installation standards.
d) That the system shall be application independent and shall support both current and future applications that use the TIA 568 component and link/channel specifications for cabling.
e) That all labor and materials and other costs attributable to the fulfillment of the Manufacturer Warranty shall be provided at no additional cost to the Owner.
2) The Manufacturer Warranty shall be:
a) Belden/CDT 25-Year Product Warranty and Lifetime Application Assurance Program, or
b) CommScope SYSTIMAX 20-Year Extended Product Warranty and Applications Assurance Program, or
c) Corning 25-Year LANScape Solutions Extended Warranty, or
d) Panduit/General Cable 25 Year Comprehensive Warranty Program (http://www.pangensolutions.com/Pages/Default.aspx), or
3) Manufacturer Warranty Period:
a) The Manufacturer Warranty Period shall commence upon Final Acceptance or a Warranty Certificate being issued by the Manufacturer, whichever is later.
4) Manufacturer Warranty Certificate:
a) The Manufacturer Warranty Certificate shall be included with the Contractor Warranty.

2. Security System(s):
   a. Replacement: Defective components which cannot be serviced within (5) five business days due to unavailability of parts or services shall be replaced with new, identical components. If new and identical components are not available, the Contractor may provide new and equal substitutes upon Owner approval. Replaced components shall become the property of the Owner and shall be warranted by the Contractor for the remaining term of the Warranty Period, or the term of Manufacturer's Warranty, whichever is longer.
   b. Preventative Maintenance: The Contractor's Warranty shall include (2) two preventative maintenance visits during the Warranty Period for the purposes of verifying equipment operation, cleaning and lubrication, minor modifications to programming, adjustment and alignment of equipment, and other services as necessary and as requested by the Owner.
      1) The Contractor shall submit a written summary of the maintenance work performed during each Preventative Maintenance visit within (5) five business days of the visit.
   c. Exclusions: Fuses and exterior finishes are specifically excluded from the Warranty, except where failure or damage is attributable to defective materials or workmanship.
3. Electrical for Communications Systems:
   a. No additional warranty items required.

PART 2 - MATERIALS

2.1 THIS SECTION NOT USED

PART 3 - EXECUTION

3.1 THIS SECTION NOT USED

END OF SECTION 270040

SECTION 270050 - QUALITY ASSURANCE

PART 1 - GENERAL

1.1 SUMMARY

A. This Section defines processes and procedures for quality assurance applicable to Division 27.

1.2 GENERAL QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

A. Design Intent Meeting
   1. The Contractor shall schedule and attend a meeting to review the design with the Engineer, Owner, and the General Contractor. The purpose of the meeting will be to ensure that the Contractor fully understands the design intent as detailed in the Contract Documents. The Contractor shall thoroughly review the Contract Documents prior to the meeting, and shall document questions, comments, and/or concerns to be discussed at the meeting. The meeting shall take place prior to Submittal preparation and submission. Attendees shall include:
      a. Communication Systems Contractor(s)
         1) Communications Cabling System
         2) Security System(s)
         3) Others as applicable
      b. Electrical Contractor
      c. General Contractor
      d. Engineer
      e. Owner

B. Pre-installation Meeting
   1. Prior to beginning work in a given area (or areas), the Contractor shall schedule and attend a pre-installation meeting to review and coordinate work within that area with the other trades. The purpose of the meeting will be to review the communications pathway/raceway layout and identify and resolve any potential conflicts, to have each trade verify that the pathway/raceway sizing is sufficient for the cabling to be installed within, to ensure a consistent installation for all cabling, to minimize interference with adjacent materials and equipment, and to ensure that communications cabling and equipment is accessible to the Owner for future modifications and maintenance. The meeting shall take place a minimum of 30 days prior to communications pathway/raceway rough-in. Attendees shall include:
      a. Communication Systems Contractor(s)
         1) Communications Cabling System
         2) Security System(s)
         3) Others as applicable
      b. Electrical Contractor
      c. General Contractor
      d. HVAC/Mechanical Contractor
      e. Plumbing Contractor
      f. Engineer

g. Owner

C. Inspections

1. The Contractor shall schedule and coordinate all inspections of the work as required by the Governing Authorities. The Contractor shall be solely responsible for scheduling inspections by the Governing Authorities at times appropriate to the stage of construction and the work to be inspected. The Contractor shall provide all assistance as required by the inspector(s) during their inspection(s).
   a. Should the Governing Authorities require remedial action on the Contractor's part due to the failure of the Contractor to schedule inspections at appropriate times, such work shall be at no additional cost to the Owner.
   b. The Contractor is solely responsible for scheduling inspections such that, should the work fail inspection, enough time remains in the project schedule to take remedial action and re-inspect the installation.

D. Observation of Work

1. Work will be observed by the Engineer on a periodic basis. Work not found to be in compliance with the Construction Documents, or not in compliance with the intent of the Construction Documents, shall be brought into compliance at no additional cost to the Owner.
2. The Contractor shall notify the Engineer at least one week in advance of the covering of concealed work so that the Engineer may schedule on-site observation of the work to be concealed. Work shall not be concealed until work has been tested (if applicable), observed by the Governing Authorities (if applicable), and at the Engineer's discretion, observed by the Engineer. Should work be concealed prior to such testing and observation, it shall be uncovered, tested, observed, and restored by the Contractor to the finished condition at no additional cost to the Owner.

E. Coordination

1. The Contractor shall thoroughly examine the Construction Documents, including Drawings and Specification Sections of other Divisions, shop drawings, or where equipment has been substituted or is proposed to be substituted for construction details and methods that are dependent upon or will affect the work of other trades. The Contractor is responsible for identifying coordination issues, discrepancies, conflicts and dependencies, and for preparing Shop Drawings, work plans and schedules to accommodate or mitigate coordination issues, discrepancies, conflicts and dependencies before they arise. Changes necessitated by the failure of the Contractor to coordinate with the work of other trades shall be at no additional cost to the Owner.
2. The Contractor shall confer and cooperate with the other trades, throughout the entire construction process, in order to coordinate the work in the proper sequence. Typical coordination issues include but are not limited to:
   a. Electrical work, including but not limited to electrical receptacles, power panels, transformers, the telecommunications grounding system, and the installation of raceway, device boxes, conduits, cable tray, ladder racking and sleeves.
   b. Mechanical work, including but not limited to HVAC systems and ductwork, piping, and mechanical chases.
   c. Ceiling cavity spaces.
   d. Installation of acoustical ceiling tiles and similar finishes that may conceal the work.
   e. Build-in of oversized equipment during structure construction.
   f. Required separation distances.

g. Access routes for equipment through the construction.
h. Cutting/coring of floor, ceiling or wall structures.

3. Verify that the physical dimensions of each item of equipment fit the available space, promptly notify the Engineer with documentation of any potential conflicts, and await the Engineer's direction prior to purchase and rough-in of the equipment. Documentation shall include narrative explanation of potential conflict supported by drawings illustrating such with suggested solution.
4. Coordinate locations of devices with field conditions, unless such locations are specifically dimensioned or otherwise noted in the Construction Documents. If so noted, verify location with other affected trades and against existing field conditions, promptly notify the Engineer of any potential conflicts, and await the Engineer's direction prior to purchase and rough-in of the equipment.
5. Coordinate locations for chases, slots, sleeves, and openings in the building structure. For new concrete coordinate, locate and provide chases, slots, sleeves, and openings prior to the pouring of the concrete.
6. Outages shall be coordinated and scheduled in advance with the Owner at a time and duration acceptable to the Owner. Outages scheduled at times other than the normal working hours shall not entitle the Contractor to additional compensation beyond the original amount bid. Outages without advance notice and prior approval by the Owner are not acceptable.
7. Furniture and Casework: Prior to procurement and installation of materials and equipment within furniture and casework, the Contractor shall coordinate with other trades and verify all locations, pathway requirements, etc. Materials and equipment installed in furniture and casework without prior coordination are solely at the Contractor's risk, and as such, are subject to possible rejection by the Engineer. Rejected materials and equipment shall be replaced and modified furniture and casework shall be restored to its original condition at no additional cost to the Owner.

F. Verification and Validation
1. Measurements
a. The Contractor shall physically verify and validate all measurements on site (i.e. actual measurements vs. those of the Drawings). Where discrepancies exist which could affect the Work or the Intent of the Construction Documents, the Contractor shall notify the Engineer and await the Engineer's direction, prior to procurement and installation of materials.
2. Raceway/Pathway Sizes
a. Prior to procurement and installation of raceway/pathway, the Contractor is responsible for verifying and validating raceway/pathway (conduit, sleeves, cable tray, surface raceway, etc.) sizes with any and all trades which will make use of them.
1) The Contractor, in conjunction with the various trades, shall determine the quantity, types, and outside diameters of the cables to be installed within each raceway/pathway, and shall verify the cable fill ratios for each pathway based upon this information. The cable fill ratios shall include spare capacity as required elsewhere within these Specifications or on the Drawings.

2) Where the calculated cable fill ratios exceed that recommended by the NEC and TIA 569, where the ratios indicate that the raceway/pathway is of insufficient size, and/or where discrepancies exist between the raceway/pathway sizes shown on the Drawings and the Contractor's calculated sizes, the Contractor shall notify the Engineer and await the Engineer's direction prior to procurement and installation of the raceway/pathway or cable.

3. Equipment locations
   a. Prior to the installation of equipment, the Contractor shall coordinate with other trades and subsequently verify all equipment locations that mount on walls or within ceilings. This work shall include but shall not be limited to:
      1) Structural elements such as lighting devices, HVAC equipment, fire protection devices, and cable tray.
      2) Structural support elements for ceiling mounted devices such as but not limited to speakers, cameras, projectors and projection screens.
      3) Backing Board for wall mounted devices such as but not limited to equipment panels, equipment panels, power supplies, head-end equipment, flat panel displays, speakers, and equipment room devices.
4. No additional compensation will be approved for additional work or materials required due to the Contractor's failure to verify and validate the above.

G. Examination
1. The Contractor shall carefully examine the project site and the Construction Documents and shall be responsible for identifying all utility, state, and local requirements that will affect the Work.
2. The Contractor shall become familiar with the local conditions under which the work is to be performed and correlate those conditions with the requirements of the Construction Documents. No allowance will be made for claims of concealed conditions which the Contractor, exercising reasonable due diligence while examining the site, observed or should have observed.
3. The Contractor shall be responsible for determining if the Work will affect the operation or code compliance of existing systems. Where this is the case, the Contractor shall notify the Engineer and await the Engineer's direction prior to procurement and installation.

1.3 SYSTEMS SPECIFIC QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

A. In addition to the quality assurance processes and procedures specified above, the Contractor shall provide the following for each system:
1. Communications Cabling System:
   a. Coordination:
      1) The Contractor shall review the Drawings and Specifications of other Divisions for locations of devices and equipment requiring communications connectivity not specified or shown on the Drawings of this Division. The Contractor shall coordinate the locations of these items with the other trades, and shall verify locations with the Engineer and Owner prior to rough-in.
      2) The Contractor shall facilitate and coordinate Service Providers installations with the Owner and with the Service Provider(s).
   b. Verification: The Contractor shall physically verify the following on site, prior to procurement and installation:

1) Backbone Cable: Verify total run lengths for each backbone cable (inside and outside plant) from origination to destination using the pathways provided (ductbank, conduits, raceway, conduit, cable-tray, sleeves, open/accessible pathways, etc.), and including slack loops, vertical transitions, jogs, etc. Pre-cut cables of insufficient length are the sole responsibility of the Contractor.
2) Station Cable: Verify total run lengths for each station cable from outlet location to communications room using the pathways provided (conduit, cable tray, sleeves, open pathways, etc.), and including slack loops, vertical transitions, jogs, etc. For run lengths which may exceed 270 feet, the Contractor shall obtain the Engineer's direction prior to proceeding with the installation.

c. Contractor RCDD Periodic Review:
1) During the course of construction, the Contractor's RCDD shall periodically perform an on-site review of the construction in progress and certify that the construction conforms to the requirements of the Governing Requirements, and in particular the TIA standards. The RCDD shall provide a written report to the Owner/Engineer on company letterhead that details the work reviewed and states that the work is in conformance with the Governing Requirements. The work in progress shall be reviewed and a report delivered to the Owner/Engineer on a bi-weekly basis.

d. Inspections:
1) Inspections shall occur no later than one week after Substantial Completion. Furthermore, inspections shall be completed and certified no later than three weeks prior to the scheduled use of the system by the Owner.
a) Manufacturer Inspection: The installation is required to pass all Manufacturer certification requirements.
i. The completed installation shall be inspected by Manufacturer personnel, shall pass the Manufacturer inspection, and shall be certified by the Manufacturer to meet and be covered by the Manufacturer extended product warranty.
ii. The Contractor is solely responsible for all costs associated with scheduling the Manufacturer inspection, the inspection itself, and for making any modifications to the installation as required by the Manufacturer at no additional cost to the Owner.
b) RCDD Inspection: The installation is required to comply with the Governing Requirements.
i. The Contractor's RCDD shall inspect the completed installation and prepare a certificate on company letterhead certifying that the work complies with the Governing Requirements. The written certification shall be complete with the RCDD's stamp/certification number and shall bear the RCDD's signature across the face of the stamp. The certification shall be submitted with the O&M documentation.

2. Security System(s):
a. Equipment locations: Prior to installation of equipment, the Contractor shall coordinate with other trades and subsequently verify all equipment locations that mount on walls or within ceilings. This work shall include but shall not be limited to:
1) Structural elements such as lighting devices, HVAC equipment, fire protection devices, and cable tray.

2) Structural support elements for ceiling mounted devices.
3) Backing Board for wall mounted devices such as equipment panels, power supplies, head-end equipment, etc..

3. Low Voltage System(s):
   a. In-Building Wireless System:
      1) Equipment locations: Prior to the installation of equipment, the Contractor shall coordinate with other trades and subsequently verify all equipment locations that mount on walls or within ceilings. This work shall include but shall not be limited to:
         a) Structural elements such as lighting devices, HVAC equipment, fire protection devices, and cable tray.
         b) Structural support elements for ceiling mounted devices.
         c) Backing Board for wall mounted devices such as equipment panels, power supplies, head-end equipment, etc..
4. Electrical (for Communications Systems)
   a. Raceway/Pathway Size Validation: The Electrical Contractor is responsible for ensuring that the Raceway/Pathway sizes have been validated by all trades per the criteria set forth in *Part 1 – General: General Quality Assurance/Quality Control (QA/QC), Verification and Validation, Raceway/Pathway Sizes* above.
      1) Where discrepancies exist between the raceway/pathway sizes shown on the Drawings and the Contractor's calculated sizes, the Contractor shall notify the Engineer and await the Engineer's direction prior to procurement and installation of the raceway/pathway.
         Materials

PART 2 - MATERIALS

2.1 THIS SECTION NOT USED

PART 3 - EXECUTION

3.1 THIS SECTION NOT USED

END OF SECTION 270050

SECTION 270060 - TRAINING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section defines training requirements for the various communications systems.

1.2 GENERAL REQUIREMENTS

A. Trainer/Instructor
   1. The Instructor leading the training session(s) shall be a qualified and experienced trainer. Where the Contractor does not have a qualified and experienced trainer on staff, the Contractor shall arrange to have appropriate Manufacturer Representative(s) lead the training session(s).
   2. The Contractor shall have the Project Manager and/or Foreman present during the training session(s) in order to assist the Instructor by providing "hands-on" operational knowledge of the installation and operations of the systems.
   3. For complex/sophisticated equipment, the Contractor shall arrange to have the appropriate Manufacturer Representatives present during the training session(s).

B. Schedule and Location
   1. The date and time of the training sessions(s) shall be coordinated with and approved by the Owner and Engineer. The Engineer may attend the training session(s) at the Engineer's discretion.
   2. The training sessions(s) shall occur within one month of Substantial Completion, unless otherwise approved by the Owner.
   3. Training session(s) shall occur at the site, in order to provide the participants with "hands-on" experience.
   4. Training may not necessarily occur in contiguous periods, depending upon the needs of the Owner (e.g. if a total of 8 hours of training is required, depending upon the needs of the Owner, it may be that two 2-hour periods and one 4-hour period spread across several weeks may be necessary).

C. Follow-up Training
   1. Unless otherwise noted, provide one follow-up training session during the Warranty Period, scheduled at the request of the Owner. The follow-up training session shall occur after the Owner has had the opportunity to fully operate the system(s). The Contract shall not be considered complete until training has been completed.

PART 2 - MATERIALS

2.1 GENERAL

A. The final version of the O&M Manual(s) shall be used as the primary training aid.

B. Training materials and presentations shall be professional in appearance, organized, bound, and suitable for re-use by the Owner in the future. Provide training materials to each participant, plus an additional 10 copies to the Owner for future use. Training materials shall be provided on CD-ROM in addition to hardcopy.

C. Recording
   1. Unless otherwise noted, the Contractor shall schedule, arrange, and provide equipment and personnel to **professionally record** the Training session(s), and shall provide the subsequent recording to the Owner in standard DVD or Blu-ray format as well as electronically in MPEG4 format.

PART 3 - EXECUTION

3.1 GENERAL

A. The Contractor shall provide training on the proper operation and routine maintenance of the various communications systems. Training shall include "hands-on" demonstrations.

B. Training shall not commence until the communications system(s) are complete, tested, and fully operational.

3.2 TRAINING

A. Provide training for each system as follows:
   1. Communications Cabling System:
      a. Training Session(s)
         1) Provide a total of 4 hour(s) of training, broken out approximately as follows:
            a) Overview of the Communications Cabling System and Warranty process: Provide 1 hour of training
            b) Backbone Cabling: Provide 1 hour of training
            c) Horizontal Cabling: Provide 1 hour of training
            d) Communications Rooms and Spaces: Provide 1 hour of training
      b. Videotaping: Not required.
      c. Follow-up Training: Not required.
   2. Security System(s):
      a. Training Sessions
         1) Provide a total of 3 hours of training, broken out approximately as follows:
            a) Overview of the Security System(s) and Warranty process: 1 hour
            b) Access Control System: 2 hours
      b. Follow-up Training Session: Provide one 2-hour session prior to 1-year warranty expiration.

3. Low Voltage System(s):
    a. In-Building Wireless System
        1) The Contractor shall conduct a training course for the operating staff as designated by the Owner. This course shall be given at the installation site during normal working hours and shall start after the system is functionally complete but prior to final acceptance. The course shall cover all of the approved operating and maintenance manuals as well as demonstrations of routine maintenance operations. The Owner shall be notified 10 days prior to the start of the training course.
        2) Provide a minimum of 2 hours of training to the Owner, at a time mutually agreed upon between the Owner and Contractor. Contractor shall notify Engineer of date and time established for training and instruction.
        3) Training and instruction shall be provided in the presence of the Engineer. This condition may be waived at the discretion of the Engineer.
    b. Training Session(s)
        1) Schedule training sessions to occur after the system is Substantially Complete but prior to Acceptance Testing.
        2) Provide a total of 5 hour(s) of training, broken out approximately as follows:
            a) Overview of the Low Voltage System(s) and Warranty process: 5 hour(s)
        3) After Acceptance Testing, update the training materials to reflect any issues, configuration changes, etc. resulting from the Testing. Provide updated materials to Owner.
    c. Follow-up Training Session: Provide one 2-hour session.
4. Electrical for Communications Systems:
    a. Not required.

END OF SECTION 270060

SECTION 270405 - COMMON WORK - SLEEVES, PENETRATIONS, AND FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes specific requirements for sleeves and penetrations common to the communications systems.

1.2 RELATED SECTIONS

A. The firestopping requirements of this Section are additional to, different from, or otherwise supplement the Section(s) in Division 7 which pertain(s) to thermal protection systems, such as firestopping and fire-resistive materials. The applicable requirements of these Section(s) shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS

A. Provide the following per the criteria set forth in Submittals in Division 27 Specification Section *Basic Communications Requirements*:
   1. Product Data

1.4 DEFINITIONS

A. EMT: Electrical Metallic Tubing

B. RMC: Rigid Metal Conduit

PART 2 - MATERIALS

2.1 GENERAL

A. Part Numbers: Refer to the Equipment Schedule(s) on the Communications Construction Drawings for specific manufacturers and part numbers. If no part number is provided, then any part meeting the manufacturer and requirements specified is acceptable.

2.2 SLEEVES

A. Provide sleeves for all locations where cable must pass-through building barriers such as walls, floors or foundations.

B. Sleeves consist of Conduit Section(s), Cable Tray Wall Penetration Sleeve Device(s), Cable Pathway Smoke and Acoustical Device(s), Cable Pathway Firestopping Device(s) or Fire Rated Floor Penetration Assemblies passing through a penetration/opening in a barrier or floor.

C. Conduit sections used for sleeves shall be per the requirements of Division 27 Specification Section *Electrical Technology - Conduit and Boxes.*

D. Sleeves through fire rated, smoke rated, and/or acoustically rated barriers shall be:
   1. Cast-in-place: Provide:
      a. Hilti Cast-In-Place Opening (CP 680M/P) equipped with:
         1) Hilti Speed Sleeve (CP 653), typical; or
         2) EMT conduit section with appropriate fill material; or
      b. RMC conduit sections; or
      c. As otherwise shown on the Drawings
   2. Cored: Provide:
      a. Hilti Speed Sleeve (CP 653) typical; or
      b. EMT conduit sections with appropriate fill material; or
      c. As otherwise shown on the Drawings

E. Cable Tray Wall Penetration Sleeve Devices shall be:
   1. Where Cable Tray is shown passing through non fire-rated, non smoke-rated, non acoustical-rated barriers provide devices pre-manufactured and designed to allow cable tray to pass through them. The Contractor shall ensure that the devices provided are sized appropriately to and compatible with the cable tray served, in accordance with the device manufacturer's recommendations. The pathway shall be UL classified and use shall be per local codes. Sleeves shall be:
      a. Superior
      b. Cablofil - PWIndustries
      c. Or approved equal

F. Smoke and Acoustic Pathway Devices/Sleeves shall be:
   1. For non fire-rated barriers/partitions that are smoke rated or where there is an acoustical transmission concern, other than floors: Cable Pathway Smoke and Acoustic Pathway Device/Sleeve.
      a. Devices shall be pre-manufactured enclosed Smoke and Acoustic Pathway Devices/Sleeves with a built-in air leakage and sound transmission system sufficient to maintain the ratings of the barrier being penetrated. The self-contained system shall easily re-penetrable and re-sealable, and adjustable to accommodate the installed cable loading. The device shall permit cables to be installed, removed, or maintained without the need to remove or reinstall materials. The pathway shall be UL classified, shall be L Ratings Tested According to Air Leakage Test Procedure as outlined in UL1479 without a Fire Test, Plenum tested to UL2043 in Horizontal Installations Only and Sound Transmission Classification (STC) tested per ASTM E90. Use shall be per local codes. Sleeves shall be:
         1) Hilti: Speed Sleeve CP 653
         2) Specified Technologies, Inc.: EZ-Path Smoke and Acoustic Pathway Device
         3) Or approved equal

G. Fire-rated Sleeves shall be:
   1. For barriers other than floors: Cable Pathway Firestopping Device
      a. Devices shall be pre-manufactured enclosed fire rated pathway devices with a built-in fire sealing system sufficient to maintain the hourly rating of the barrier being penetrated. The self-contained sealing system shall automatically adjust to the installed cable loading and shall permit cables to be installed, removed, or maintained without the need to remove or reinstall firestop materials. The pathway shall be UL classified and FM/Systems approved, and shall be examined and tested to the requirements of ASTM E814 (UL1479). Use shall be per local codes. Sleeves shall be:
         1) Hilti: Speed Sleeve CP 653
         2) Specified Technologies, Inc.: EZ-Path
         3) Wiremold: FlameStopper
         4) Or approved equal
      b. For Cable Pathway Firestopping Devices sizes 3-inch and larger provide a Radius Drop Guide (also known as Radius Control Module or Conduit Waterfall) for each device. Manufacturer shall be:
         1) Panduit: Conduit Waterfall CWF400
         2) Specified Technologies, Inc.: EZ-Path
   2. Floor Penetration Assemblies: For penetrations through fire rated floors, provide one of the solutions described in sub-paragraphs below:
      a. Provide a round re-penetrable re-sealable fire-rated cable management device. The fire-rated cable management device shall consist of a corrugated steel tube with zinc coating, contain and inner plastic housing, intumescent material rings, and inner fabric smoke seal membrane. The length of the sleeve shall be 12.4 inches. The fire-rated cable management device shall contain integrated intumescent firestop wrap strip materials sufficient to maintain the hourly rating of the barrier being penetrated. The fire-rated cable management device shall contain a smoke seal fabric membrane or intumescent firestop plugs sufficient to achieve the L-Rating requirements of the barrier type. The fire rated cable management device shall be:
         1) Hilti: Speed Sleeve (CP653) with integrated smoke seal fabric membrane.
         2) Hilti: Cast-In-Place opening (CP 680M/P)

2.3 FIRESTOPPING

A. General:
   1. Provide firestopping material for all through and membrane penetrations of fire-rated barriers.
   2. Firestopping material used to seal open penetrations through which cable passes shall be re-usable/re-enterable.
   3. Provide through-penetration firestop products that are compatible with one another, with the substrates forming openings, and with the penetrating items.
   4. Provide firestop products that upon curing do not re-emulsify, dissolve, leach, breakdown or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water or other forms of moisture characteristic during and after construction.

5. Provide firestop sealants sufficiently flexible to accommodate motion such as pipe vibration, water hammer, thermal expansion and other normal building movement without damage to the seal.
6. Materials or sealants shall not contain flammable solvents or sodium silicate.
7. Products specified in this Section shall be UL Listed and Labeled.

B. Firestopping Materials
1. Material shall conform to both Flame (F) and Temperature (T) ratings as required by local building codes and as tested by nationally accepted test agencies per ASTM E814 or UL 1479 fire test in a configuration that is representative of the actual field conditions. Materials shall be complete with necessary accessory materials, as applicable, for complete UL listed and approved assemblies.
   a. Firestopping materials shall be manufactured by:
      1) Hilti
      2) Specified Technologies. Inc.
      3) Or approved equal

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section *Basic Communications Requirements*. Governing Requirements of particular relevance to this Section include, but are not limited to:
1. NEC: National Electrical Code (NFPA Article 70)
2. TIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces

B. Installation shall be such that communications circuits, when installed in the pathways and penetrations specified herein, are able to fully comply with the following:
1. TIA 568: Commercial Building Telecommunications Cabling Standard

3.2 SLEEVES

A. Provide sleeves for all locations where free hung cable must pass through building barriers such as walls, floors or foundations.

B. The Contractor shall provide all cutting, rough patching and finish patching as required for the installation of sleeves, and shall provide all penetrations, including core drilling, roto-hammering, etc. as required.

C. Sleeves shall be sealed and firestopped (as appropriate to the fire rating of the barrier) between the conduit section (or cable pathway firestopping device) and the barrier penetration/opening.

D. Sleeve size shown on the Drawings reflects the size of the conduit or device passing through, not the size of the penetration/opening.

E. Conduit section sleeves:
   1. Conduits shall be installed per the requirements of Division 27 Specification Section *Electrical Technology - Conduit and Boxes.*
   2. Conduit sections shall be installed complete with insulated throat bushings.
   3. Conduit Sleeve Sizing:
      a. Unless otherwise noted on the Drawings, sleeve size through floors shall be 4-inch diameter, with quantity of sleeves sufficient to accommodate planned cabling, plus additional sleeve(s) to provide at least 25 percent for future expansion.
      b. Unless otherwise noted on the Drawings or specified herein, sleeves shall be sized as follows:
         1) Where cable trays must pass through a non-fire rated barrier. Transition from cable tray to Conduit Sleeve(s) at non-fire rated barriers.
            a) Provide sufficient quantity of conduit sleeves such that the combined useable cross sectional area of the devices matches or exceeds the cross sectional area of cable tray to be served.
         2) Where free hung cables must pass through non-fire rated barriers.
            a) Provide sufficient quantity of conduit sleeves according to the quantity and outside diameter of the cable(s) they are to support per NEC fill ratios and TIA 569 cable capacity standards, plus an additional 25 percent for future expansion.

F. Cable Tray Wall Penetrating Sleeve Devices:
   1. Provide for all instances where cable trays must pass through non-fire rated barriers.
   2. Install per Manufacturers' recommendations.
   3. Contractor shall be responsible for ensuring that the Cable Tray Wall Penetration Sleeve Devices are sized appropriately and compatible with the cable tray being served.

G. Smoke and Acoustic Pathway Device/Sleeve:
   1. Provide Smoke and Acoustic Pathway Devices for locations where cable will penetrate through a non-fire rated barrier that is smoke rated or where there is an acoustical transmission concern such as in locations where adjacent rooms have no ceilings. Refer to architectural drawings for wall and ceiling type information.
      a. Unless otherwise noted on the Drawings or specified herein, Pathway Device/Sleeve shall be sized as follows:
         1) Where cable trays must pass through a non-fire rated barrier that is smoke rated or where there is an acoustical transmission concern transition from cable tray to Smoke and Acoustic Pathway Device(s)/Sleeve(s).
            a) Provide sufficient quantity of Smoke and Acoustic Pathway Devices/Sleeves such that the combined useable cross sectional area of the devices matches or exceeds the cross sectional area of cable tray to be served.
         2) Where free hung cables must pass through a non-fire rated barrier that is smoke rated or where there is an acoustical transmission concern:
            a) Provide sufficient quantity of Smoke and Acoustic Pathway Devices/Sleeves according to the quantity and outside diameter of the cable(s) they are to support per NEC fill ratios and TIA 569 cable capacity standards, plus an additional 25 percent for future expansion.

H. Cable Pathway Firestopping Device:
   1. Where cable trays must pass through fire rated barriers. Transition from cable tray to Cable Pathway Firestopping Devices at fire rated barriers.
      a. Provide sufficient quantity of cable pathway firestopping devices such that the combined useable cross sectional area of the devices matches or exceeds the cross sectional area of cable tray to be served.
   2. Where free hung cables must pass through fire rated barriers.
      a. Provide sufficient quantity of cable pathway firestopping devices such that the combined useable capacity of the devices is a minimum of 150% of the cable to be served.

I. Fire Rated Floor Penetration Assembly:
   1. Provide where shown on Drawings.
   2. Install strictly in accordance with Manufacturer's installation guide and applicable codes.

3.3 PENETRATIONS

A. Properly size and locate penetrations required as construction progresses. For new concrete or masonry the Contractor shall coordinate, locate and provide required openings prior to the pouring of concrete or construction of masonry.

B. Penetration of concrete and structural elements shall be avoided where possible. Where not possible, obtain written approval from the Structural Engineer/Architect prior to penetration. Such penetrations shall be performed in a manner that will not reduce structural element load-carrying capacity or load-deflection ratio.

C. Penetrations shall be performed by workers qualified and skilled in the trades involved.

D. Penetrations (through and membrane) of fire rated barriers shall be firestopped and sealed. The fire rating of the barrier shall be strictly maintained.

E. Penetrations shall not be exposed on the exterior or in occupied spaces in a manner that would, in the Engineer's opinion, reduce the aesthetic qualities of the structure or result in visual evidence of penetration and patching.

F. Penetrations shall be constructed using methods least likely to damage elements to be retained or adjoining construction.
   1. Provide temporary support for the work to be penetrated.
   2. In general, where cutting is required, use hand or small power tools designed for sawing or grinding, not for hammering or chopping. Cut holes and slots neatly to required size with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
   3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring of existing finished surfaces.
   4. Cut through concrete and masonry using a cutting device such as a Barborundum saw or diamond core drill.

G. Voids around penetrations shall be properly sealed, caulked or grouted as required.

H. Existing elements:
   1. The Contractor shall be responsible for identifying, locating, and protecting existing elements such as embedded conduits, pipe, ductwork, etc. when penetrating existing structures.
   2. Cap, valve, plug or seal remaining portions of cut pipes or conduit to prevent entrance of moisture or other foreign matter.
   3. The Contractor shall be responsible for repairing or replacing existing conduits, pipe, ductwork, etc. damaged by the Contractor during construction of penetrations. Repair or replacement shall be made at no additional cost to the Owner.

I. Penetrations (and subsequent patching) resulting from the Contractor's failure to properly coordinate penetrations shall be at no additional cost to the Owner.

J. Penetrations shall be laid out and installed in advance to facilitate the installation of raceway through the penetrations.

3.4 FIRESTOPPING

A. Work shall be in accordance with the UL Fire Resistance Directory, fire test reports, fire resistance requirements, acceptable sample installations, manufacturer's recommendations, local fire and building authorities, and codes.

B. Application of sealing material shall be accomplished in a manner acceptable to the local fire and building authorities.

C. The fire rating of all penetrated fire barriers shall be strictly maintained. All through penetrations as well as membrane penetrations of fire rated barriers shall be firestopped and sealed.

D. Installation shall be performed in strict accordance with manufacturer's detailed installation procedures. Prepare surfaces per manufacturer's instructions. After installation, clean all surfaces adjacent to sealed openings to be free of excess firestopping materials and soiling.

E. Personnel installing firestopping products shall be certified by the Manufacturer to install such products.

F. Install firestopping in open penetrations and in the annular space of penetrations for fire rated barriers.

G. Seal all openings or voids made by penetrations to ensure an air and water resistant seal.

H. Install firestopping such that the performance and effectiveness of other thermal and fire protective devices (such as fire/smoke dampers) in the area are fully maintained.

I. Install putty pads in conjunction with metallic boxes where size or aggregate area of such boxes exceed limits established by the governing requirements.

J. Protect materials from damage on surfaces subjected to traffic.

K. Apply a suitable bond-breaker to prevent three-sided adhesion in applications where this condition might occur such as the intersection of a gypsum wallboard/steel stud wall to floor or roof assembly where the joint is backed by a steel ceiling runner or track.

L. Where joint application is exposed to the elements, fire resistive joint sealant must be approved by the manufacturer for use in exterior applications and shall comply with ASTM C-920.

M. Do not install firestop products when ambient or substrate temperatures are outside limitations recommended by the manufacturer.

N. Do not install firestop products when substrates are wet due to rain, frost, condensation or other causes.

O. Schedule installation of firestopping after completion of penetrating item installation but prior to covering or concealing openings.

P. Firestopping devices shall not act as supports.

END OF SECTION 270405

SECTION 270406 - COMMON WORK - HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes specific requirements for hangers and supports within the Communications Pathway System. General requirements are covered in Division 27 Specification Section *Electrical Technology - General Requirements.*

1.2 RELATED SECTIONS

A. The requirements of Division 27 Specification Section *Electrical Technology - General Requirements* shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS

A. Provide the following per the criteria set forth in Submittals in Division 27 Specification Section *Basic Communications Requirements*:
   1. Product Data

1.4 DEFINITIONS

A. Hanger/Support System: All equipment, materials, and incidentals required to support the raceway/pathway and cabling systems, including but not limited to metallic hangers and supports, conduit, cable tray, conduit, pull boxes, device boxes, u-channels, threaded rods, clamps, concrete inserts, anchor bolts, cables, backing boards, etc.

PART 2 - MATERIALS

2.1 GENERAL

A. Part Numbers: Refer to the Equipment Schedule(s) on the Communications Construction Drawings for specific manufacturers and part numbers. If no part number is provided, then any part meeting the manufacturer and requirements specified is acceptable.

2.2 HANGERS AND SUPPORTS

A. A complete Hanger/Support System shall be provided to support all components of the raceway/pathway and cabling systems.

B. The Contractor shall provide all materials, labor and incidentals as required for a complete Hanger/Support System.

C. The Hanger/Support System shall be of corrosion resistant or galvanized steel, shall be of an approved standard design, and shall be constructed to maintain the supported load in proper position and alignment under all operating conditions. Manufacturer shall be:
   1. B-line
   2. Caddy/Erico
   3. Kindorf
   4. Unistrut
   5. or Equal

2.3 CABLE SUPPORTS (J-HOOKS, STRAPS)

A. Cable supports exterior to Communications Equipment Rooms:
   1. Provide cable supports suitable for the quantity of cables to be supported where Cable Tray or Conduit Raceway is not provided per the Construction Documents. Cable supports shall be complete with all incidental materials and assemblies required, including but not limited to mounting accessories to independently support supports from structure, extender brackets for mounting multiple hooks on a single support, clamps and fasteners, dedicated support wires, purlins and cable retainers as required. Supports, incidental materials, cable ties and cable retainers shall be plenum or non-plenum rated to match that of associated cable, and shall be listed to UL Standard 2239. Supports shall be:
      a. Wide Base Cable Supports (J-Hooks): Supports shall be wide-based (minimum 1-inch) with flared edges. Provide larger sizes and multiple supports as required by cable quantities.
      b. Straps/Slings: Straps/slings shall be wide-based (minimum) 2-inch and adjustable. Provide sizes, quantities and universal mounting equipment as required.

B. Cable straps within Communications Equipment Rooms:
   1. Cable Straps shall be used within communications rooms and spaces and shall be provided for strapping groups of cables to raceway and for controlling/managing patch cables. The use of plastic tie wraps for this purpose is not acceptable. Cable straps shall be self-gripping, reusable, constructed of Velcro, and hook-and-loop style. Cable straps shall be plenum or non-plenum rated to match that of associated cable. Cable straps shall be manufactured by:
      a. Velcro
      b. Siemens
      c. Panduit
      d. Approved Equal
   2. Size: Cable strap size shall be:
      a. For Patch Cables: ½ inch wide and minimum 8/maximum 12 inches in length.
      b. For Horizontal Cables: ½ inch wide and minimum 8/maximum 12 inches in length.
      c. For Backbone Cables: ¾ inch wide and minimum 12/maximum 18 inches in length.
   3. Color: Cable strap color shall be the same color as the cable color of the bundle to be strapped.

PART 3 - EXECUTION

3.1 HANGERS AND SUPPORTS

A. Hanger/Support system shall be installed in such a manner as to prevent any strain being imposed on the equipment supported.

B. Coordinate with the building structure and the work of other trades.

C. Install individual and multiple trapeze raceway hangers and riser clamps as necessary to support raceways. Provide all incidental materials as necessary for hanger assembly and for securing hanger rods and conduits. Use 3/8 inch diameter or larger all-thread rods for support.

D. NEC requirements:
   1. Hangers and supports shall be installed at required intervals.
   2. Conduit, hangers and supports, cable, or infrastructure related to Communications Systems, shall not be secured to, or supported by, the ceiling assembly, including the ceiling support wires. An independent (dedicated) means of secure support shall be provided.
   3. Wires provided as dedicated hangers for supports shall be secured at both ends, such as the structural ceiling at one end and the suspended ceiling grid at the other end, and shall be distinguishable from wire used to support the suspended ceiling assembly by color, tagging, or other effective means.

E. In exposed structural ceiling spaces, where no suspended ceiling assembly is indicated, wire shall not be used as a hanger for supports.

F. Strength of each support shall be adequate to support a minimum of five times the present and future load. A minimum of 200 pound safety allowance for each support is required.

G. Cut threaded rods such that the bottoms have a maximum length of thread below the bottom nut equal to that of the rod diameter (i.e. a 3/8 inch rod would have a maximum length of 3/8 inches below the bottom nut).

H. Conduit and box support installation shall prevent displacement of conduit and box in any direction.

I. Provide plastic or rubber end caps for all Hanger/Support System components which are readily accessible and exposed to personnel.

J. Anchor Methods:
   1. Verify all allowable Anchor Methods with the General Contractor, Owner, Structural Engineer, and Structural Construction Documents prior to performing any work. Not all methods listed below may be allowed depending on the Structural Design / Elements.
      a. Hollow Masonry: Toggle bolts or spider type expansion anchors.
      b. Solid Masonry (excluding concrete): Steel expansion bolts.
      c. New Concrete: Preset inserts with machine screws and bolts.
      d. Existing Concrete: Steel expansion bolts or explosive powder driven inserts.
         1) Coordinate with structural engineer for approval of explosive powder driven inserts prior to installation.

e. Wood surfaces: Wood screws.
f. Steel: Welded threaded studs or galvanized steel clamps.
g. Light Steel: Sheet metal screws.

K. Firestopping devices shall not act as supports.

3.2 CABLE SUPPORTS (J-HOOKS, STRAPS)

A. Exterior to Communications Equipment Rooms:
1. Cable supports shall be used to support cables in accessible ceiling environments (excluding exposed ceiling spaces) where cable tray or conduit is not provided per the Construction Documents. Multiple supports at hanger locations shall be provided as required by the quantity of cables to be supported (subject to the maximum load which can be supported by the hanger) as well as cable segregation requirements (see below).
2. Cable supports may be affixed to structural members or other supports, but shall not be attached to pipes, electrical conduit, mechanical items, existing cables, or the ceiling support system. Supports shall be hung from all thread rods, dedicated #8 galvanized wires, or from brackets connected directly to structure, and shall be installed above accessible ceilings.
3. Where cable pathways are shown on the Drawings, the Contractor shall follow the indicated pathways as closely as possible, subject to field conditions. Pathways, where not shown, including pathways for small cable counts, shall be designed and documented on the As-built drawings maintained by the Contractor. Supports shall be installed parallel and perpendicular to building lines.
4. Cable supports shall be mounted at varying intervals with each interval not to exceed 5 feet. Supports shall also be placed at all changes of direction. The Contractor shall ensure that intervals between cable supports shall vary along the pathway (i.e. a given interval should not be exactly the same length as the interval preceding or following it – "exact" intervals can degrade cable performance).
5. Cable supports shall not support more cables than for which they were designed and shall not exceed 50 percent of the manufacturer's recommended fill. Multiple cable supports shall be provided where the total cable fill exceeds this amount.
6. Installation of supports shall be fully coordinated with other elements such as mechanical ductwork, piping/plumbing, electrical conduit, and other systems such that the supports remain fully accessible after installation.
7. Group cabling in separate supports by the type of Communications System (Communications, Audiovisual, Security, etc.). Different systems shall not share cable supports.

B. Within Communications Equipment Rooms:
1. Install cable straps to secure cable bundles (see below) to cable runway and other supporting equipment. The use of plastic tie wraps for this purpose is not acceptable.
   a. Bundling:
      1) Cables shall be bundled by application (patch, horizontal, backbone) and by cable type (Cat 3, Cat 5E, Cat 6, Cat 6a, MM Fiber, SM Fiber, etc.). Cable applications and types shall not be intermixed within a bundle.
      2) Cable bundles (of a given application and cable type) shall consist of relatively even cable quantities.
   b. Quantity of cable per cable bundle shall be as follows:

1) For Patch Cables: 24 to 48 patch cables per cable bundle with straps applied at 1 foot intervals.
2) For Horizontal Cables: 50 to 100 horizontal cables per cable bundle with straps applied at 3 foot intervals.
3) For Backbone Cables: 4 to 8 backbone cables per cable bundle with straps applied at 3 foot intervals.

c. Provide excess cable straps to Owner.

END OF SECTION 270406

SECTION 270500 - ELECTRICAL TECHNOLOGY - GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general requirements for raceway, pathways, grounding and bonding, and other electrical infrastructure necessary for the support of Communications Systems.

1.2 RELATED SECTIONS

A. The requirements of this Section are additional to, different from, or otherwise supplement similar Section(s) in Division 16. The applicable requirements of those Section(s) shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

B. Division 27 Specification Section *Common Work - Sleeves, Penetrations and Firestopping.* Provide sleeves, penetrations, and firestopping as required to support the work of this Section.

C. Division 27 Specification Section *Common Work – Hangers and Supports.* Provide hangers and supports as required to support the work of this Section.

D. Division 28 Specification Section(s) *for Security System(s)*.

1.3 SUBMITTALS

A. Provide the following per the criteria set forth in Submittals in Division 27 Specification Section *Basic Communications Requirements*:
   1. Product Data
   2. Shop Drawings:
      a. Raceway/pathway routing plan (including underslab, underfloor, and OSP conduit/ducts):
         1) Provide a routing if such plan has not been shown on the Drawings, or if the Contractor is proposing a deviation from that shown. The routing plan shall include:
            a) Complete floor plans or detail drawings showing the proposed routing and raceway sizes and locations, submitted in a manner equal to that of the Construction Drawings.
            b) A statement that the proposed routing has been coordinated with electrical, HVAC, plumbing, and other trades, and that comparable changes have been made to the cabling systems making use of the routing. Specifically note each location where the proposed routing is different from the Drawings, and the reason for the deviation.
            c) Routing deviations must be approved in writing by the Engineer prior to proceeding with installation.

2) If a routing plan is not required, submit written documentation stating that:
   a) The raceway/pathway routing will be provided as shown on the Drawings,
   b) The Contractor has reviewed the routing shown on the Drawings with the other applicable trades and that it does not create conflicts between the trades
   c) The raceway/pathway routing meets applicable codes, regulations and standards.

3. Other:
   a. Owner Specific: Submit other information as required by Owner Specific Governing Requirements in Specification Section *Basic Communications Requirements*.

PART 2 - MATERIALS

2.1 THIS SECTION NOT USED

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section *Basic Communications Requirements*. Governing Requirements of particular relevance to this Section include, but are not limited to:
   1. NEC: National Electrical Code (NFPA Article 70)
   2. TIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
   3. TIA 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
   4. ANSI/NECA/BICSI 607: Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings
   5. ANSI J-STD-607: Commercial Building Grounding and Bonding Requirements for Telecommunications

B. Installation shall be such that communications circuits, when installed in the pathway systems specified herein, are able to fully comply with the following:
   1. TIA 568: Commercial Building Telecommunications Cabling Standard

C. Unless otherwise noted on the Drawings or specified herein, communications raceway/pathways (conduit, sleeves, cable tray, surface raceway, etc.) shall be sized according to the quantity and outside diameter of the cable(s) they are to support per NEC fill ratios and TIA 569 cable capacity standards, plus an additional 25 percent for future expansion.

D. Firestopping: All penetrations of fire rated barriers shall be firestopped and sealed. The fire rating of all fire barriers shall be strictly maintained.

E. Labels/identification: Label and identify components of the pathway system per TIA 606.

END OF SECTION 270500

SECTION 270526 - ELECTRICAL TECHNOLOGY - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes specific requirements for the Telecommunications Grounding and Bonding System to provide a permanent bonding infrastructure for communications systems.

B. The Telecommunications Grounding and Bonding System is bonded to the building grounding system and performance is dependent upon the building grounding system – the AC Electrode Grounding System and the Equipment Grounding System specified in Division 26 *Specification Electrical – Grounding and Bonding for Electrical Systems*.

C. General requirements are covered in Division 27 Specification Section *Electrical Technology - General Requirements*.

1.2 RELATED SECTIONS

A. The requirements of Division 27 Specification Section *Electrical Technology - General Requirements* shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

B. The requirements of Division 26 Specification Section *Electrical - Grounding and Bonding for Electrical Systems* shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

C. This Section may expand upon or supplement the requirements of Division 26 Specification Section *Electrical - Grounding and Bonding for Electrical Systems*. In the event of a conflict or discrepancy between this Section and the requirements of Division 26 Specification Section *Electrical - Grounding and Bonding for Electrical Systems*, the requirements of Division 26 Specification Section *Electrical - Grounding and Bonding for Electrical Systems* shall govern and notification of such discrepancy shall be submitted to the Engineer. However, if the requirement of this Section (or portion thereof) exceeds that of the requirements of Division 26 Specification Section *Electrical - Grounding and Bonding for Electrical Systems*, and is furthermore not contrary to the requirements of Division 26 Specification Section *Electrical - Grounding and Bonding for Electrical Systems*, then the requirement of this Section (or portion thereof) shall prevail.

D. Detail TE-GS – Typical Grounding and Bonding System Detail located on the Communications Construction Drawings.

1.3 SUBMITTALS

A. Comply with the Submittal portion of Division 27 Specification Section *Basic Communications Requirements*. Provide submittal information for the following:
   1. Product Data

1.4 DEFINITIONS

A. BCT: Bonding Conductor for Telecommunications: Conductor that bonds the TMGB to the AC Grounding Electrode System.

B. EF: Entrance Facility: Entrance to a building for both public and private network service cables. May be located in an ER or TR.

C. ER: Equipment Room: Environmentally controlled centralized space of telecommunications equipment. Sometimes referred to as Main Distribution Frame (MDF), Data Center (DC), or server room.

D. GE: Grounding Equalizer: Bonding conductor that bonds TGBs on the same floor of a structure.

E. TBB: Telecommunications Bonding Backbone: Bonding conductor that bonds the Telecommunications Main Grounding Busbar to one or more Telecommunications Grounding Busbars.

F. TE: Telecommunication Enclosure: Floor or tenant serving space (enclosure or cabinet) that provides a connection point between backbone and horizontal infrastructures. Sometimes referred to as an Intermediate Distribution Frame (IDF) or Floor Distributer (FD).

G. TEBC: Telecommunications Equipment Bonding Conductor: Bonding conductor that bonds all non-current carrying metal telecommunications equipment and materials to the nearest TGB or TMGB.

H. TGB: Telecommunications Grounding Busbar: Busbar used to connect TEBCs and TBBs in a specific room. TGB is generally connected (bonded) to building structural steel, the nearest low-voltage electrical distribution panel and to the Telecommunications Main Grounding Busbar via the TBB. There is typically one (possibly more) Telecommunications Grounding Busbar per telecommunication room or equipment room.

I. TMGB: Telecommunications Main Grounding Busbar: Busbar bonded to the electrical service ground (Intersystem Bonding Termination). Origination of the TBB. There is typically one Telecommunications Main Grounding Busbar per building, located in near the communications entrance facility (EF) or in the main telecommunications room (MDF) or Building Distributer (BD).

J. TR: Telecommunication Room: Floor or tenant serving space that provides a connection point between backbone and horizontal infrastructures. Sometimes referred to as an Intermediate Distribution Frame (IDF) or Floor Distributer (FD).

PART 2 - MATERIALS

2.1 GENERAL

A. Manufacturer: Communications grounding and bonding equipment and materials shall be manufactured by a single Manufacturer unless specifically stated otherwise. The manufacturer shall be:
   1. Chatsworth Products, Inc. (CPI)
   2. Erico
   3. Cooper B-Line

B. Part Numbers: Refer to the Equipment Schedule(s) on the Communications Construction Drawings for specific manufacturers and part numbers. If no part number is provided, then any part meeting the manufacturer and requirements specified is acceptable.

C. Labels/Identification: Provide labels to identify of all components of the communications grounding and bonding system. Labels shall be permanent (i.e. not subject to fading or erasure) and permanently affixed. Handwritten labels are not acceptable.

D. Equipment and materials in this Section shall be UL Listed and Labeled.

2.2 GROUNDING BUSBARS

A. Grounding busbars shall meet the specifications of ANSI/NECA/BICSI 607 and ANSI J-STD-607 and conform to BICSI recommendations, with standard NEMA bolt hole sizing. Grounding busbars shall be predrilled copper busbars plated for reduced contact resistance and have minimum dimension of 1/4 inch thick by width and length listed below:
   1. Telecommunications Main Grounding Busbar (TMGB): TMGBs shall be a minimum of 4 inches wide and have a minimum length of 20 inches. Provide busbar with required quantity of two-hole lugs for application. Provide as shown on the Drawings. Where not shown, provide one TMGB per primary telecommunications room (e.g. EF, ER, etc.).
   2. Telecommunications Grounding Busbar (TGB): TGBs shall be a minimum of 2 inches wide and have a minimum length of 12 inches. Provide busbar with required quantity of two-hole lugs for application. Provide as shown on the Drawings. Where not shown, provide a minimum of one TGB per secondary communications room (e.g. TE, TR, ER, etc.).

2.3 BCT

A. Provide insulated green, insulated green with yellow strip, or un-insulated - copper conductor properly sized according to length of conductor and size of AC Grounding Electrode Conductor for the electrical service per NEC, TDMM, and IAEI calculations.

2.4 GE

A. Provide insulated green, insulated green with yellow strip, or un-insulated - copper conductor. Unless otherwise noted on the Drawings, conductors shall be sized according to conductor length as follows:
   1. Less than 13 feet: #6 AWG
   2. 13 to 20 feet: #4 AWG
   3. 20 to 26 feet: #3 AWG
   4. 26 to 33 feet: #2 AWG
   5. 33 to 44 feet: #1 AWG
   6. 44 to 52 feet: #1/0 AWG
   7. 52 to 66 feet: #2/0 AWG
   8. Greater than 66 feet: #3/0 AWG

2.5 TBB

A. Provide insulated green, insulated green with yellow strip, or un-insulated - copper conductor. Unless otherwise noted on the Drawings, conductors shall be sized according to conductor length as follows:
   1. Less than 13 feet: #6 AWG
   2. 13 to 20 feet: #4 AWG
   3. 20 to 26 feet: #3 AWG
   4. 26 to 33 feet: #2 AWG
   5. 33 to 44 feet: #1 AWG
   6. 44 to 52 feet: #1/0 AWG
   7. 52 to 66 feet: #2/0 AWG
   8. Greater than 66 feet: #3/0 AWG

2.6 TEBC

A. Provide insulated green or insulated green with yellow strip - 6 AWG copper conductor not to exceed 100 feet in length.

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section Basic Communications Requirements. Governing Requirements of particular relevance to this Section include, but are not limited to:
   1. ANSI/NECA/BICSI 607: Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings
   2. ANSI J-STD-607: Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
   3. NEC: National Electric Code (NFPA Article 70)
   4. UL 467: Grounding and Bonding Equipment

B. Contractor shall ensure that positive bonding connections are made to bare metallic surfaces, equipment, materials and hardware by removing surface corrosion, oxidation and paint prior to connection.

C. Where possible, bonds to structural steel shall be exothermic.

D. Where possible, exothermic or irreversible compression-type connections and two-hole lugs shall be used to terminate bonding conductors.

E. Labels/Identification: Label and identify all components of the communications grounding and bonding system.

3.2 GROUNDING BUSBARS:

A. Arrange telecommunication primary and secondary protector bonding, busbar bonding (e.g., BCT, GE, TBB, etc.) and approved building grounding conductors (e.g., toward the left, leaving space for equipment bonding conductors (e.g., TEBC, etc.) to the right.
   1. TMGB:
      a. Directly bond TMGB to:
         1) Building structural steel (if building structural steel is approved building grounding system) via bonding conductor sized per BCT calculations – minimum size of 2/0 AWG copper conductor.
         2) Intersystem Bonding Termination via BCT if BCT is less than 30 feet in length or if BCT length is shorter than bonding conductor length to nearest low-voltage electrical distribution panel.
         3) Nearest low-voltage electrical distribution panel if Intersystem Bonding Termination is not available.
         4) TGBs via TBBs as shown on drawings.
      b. Label with “TMGB”.
   2. TGB:
      a. Directly bond TGB to:
         1) Building structural steel (if building structural steel is approved building grounding system) via bonding conductor sized per BCT calculations – minimum size of 2/0 AWG copper conductor.
         2) Nearest low-voltage electrical distribution panel
         3) TMGB via TBBs as shown on drawings.
         4) TGBs via TBBs as shown on drawings.
         5) TGBs via GEs as shown on drawings.
         6) Telecommunications equipment and materials via TEBCs.
      b. Label with “TGB”.

3.3 GE

A. GEs shall be used to connect TGBs to other TGBs on designated floors. Route along the shortest and straightest path possible with minimal bends. Bends shall be sweeping. GEs shall be continuous (without splices), and shall be insulated from their support.

B. Label with “WARNING! TELECOMMUNICATIONS GROUNDING EQUALIZER (GE). DO NOT REMOVE OR DISCONNECT!” Labels shall be affixed at both ends and at accessible intermediate points.

3.4 TBB

A. TBBs shall be used to connect the TMGB to each TGB and TGB to TGB. Route along the shortest and straightest path possible with minimal bends. Bends shall be sweeping. TBBs shall be continuous (without splices), and shall be insulated from their support.

B. Label with “WARNING! TELECOMMUNICATIONS BONDING BACKBONE (TBB). DO NOT REMOVE OR DISCONNECT!” Labels shall be affixed at both ends and at accessible intermediate points.

3.5 TEBC

A. TEBCs shall be used to bond all non-current carrying metal telecommunications equipment and materials to the nearest TGB. Route along the shortest and straightest path possible with minimal bends. Bends shall be sweeping. TEBCs shall be continuous (without splices), and shall be insulated from their support.

B. Label with “WARNING! TELECOMMUNICATIONS EQUIPMENT BONDING CONDUCTOR (TEBC). DO NOT REMOVE OR DISCONNECT!” Labels shall be affixed at both ends and at accessible intermediate points.

3.6 QUALITY ASSURANCE AND TESTING

A. Visual inspection and correction of:
   1. Loose connections
   2. Corrosion
   3. Physical damage
   4. System modifications
   5. Correct and visible labeling

B. Test Integrity of Bonding Connections
   1. Perform two-point bonding measurements using an earth grounding resistance tester configured for continuity test per manufacturer’s recommendations setup and safety precautions.
      a. Measure between TMGB or TGB and nearest available grounding electrode (e.g., structural steel). Maximum value between two points shall be 0.1 ohm.
      b. Measure between equipment, equipment racks, ladder racks, rack grounding busbars and TMGB or TGB. Maximum value between two points shall be 0.1 ohm.
      c. Bonding resistance between any two conductive points in the EF, ER, TE, or TR shall not exceed 0.1 ohms.

2. Forward copy of test results to Engineer.

END OF SECTION 260526

SECTION 270533 - ELECTRICAL TECHNOLOGY - CONDUIT AND BOXES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes specific requirements for conduits and boxes within the Communications Pathway System as defined in Division 27 Specification Section *Basic Communications Requirements*. General requirements are covered in Division 27 Specification Section *Electrical Technology - General Requirements.*

1.2 RELATED SECTIONS

A. The requirements of Division 27 Specification Section *Electrical Technology - General Requirements* shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

B. Division 27 Specification Section *Electrical Technology – Underground Ducts and Raceways.*

1.3 SUBMITTALS

A. Comply with the Submittal portion of Division 27 Specification Section *Basic Communications Requirements*. Provide submittal information for the following:
   1. Product Data

1.4 DEFINITIONS

A. EMT: Electrical Metallic Tubing

B. RMC: Rigid Metal Conduit

C. RNC: Rigid Nonmetallic Conduit

D. IMC: Intermediate Metal Conduit

E. Back Box: A pre-manufactured metallic or non-metallic box mounted within a floor, wall or ceiling and used to hold Communications Systems outlets/connectors, transition devices or equipment.

F. Device Boxes: Device boxes are Back Boxes that serve as a support point and/or an enclosure for various Communications Systems (Audiovisual Systems, Communications Cabling (Telecom) System, Low-Voltage Systems and Security Systems) devices. Device boxes for Communications Systems devices other than Communications Cabling System devices typically have manufacturers' specific requirements that are identified elsewhere in the Construction Documents.

G. Outlet Box(es): Outlet box is another term used for Device Box.

PART 2 - MATERIALS

2.1 GENERAL

A. Part Numbers: Refer to the Equipment Schedule(s) on the Communications Construction Drawings for specific manufacturers and part numbers. If no part number is provided, then any part meeting the manufacturer and requirements specified is acceptable.

B. Refer to all of the Communications (Technology) System Details on the Communications Construction Drawings for additional requirements including, but not limited to Outlet Box size, Mud Ring gang size, conduit size and quantity and conduit routing. The Outlet Box size, Mud Ring gang size, conduit size and quantity and conduit routing requirements in the Details supersede the general Outlet Box size, Mud Ring gang size, conduit size and quantity and conduit routing requirements listed in this specification.

2.2 CONDUIT

A. Conduit types:
   1. EMT shall be steel, hot-dipped galvanized or electro-galvanized, with an inner coating to protect cables and aid pulling, UL listed, and meeting the requirements of UL 797 and ANSI C80.3.
   2. RMC shall be steel, hot-dipped galvanized inside and outside with factory threaded ends full cut and galvanized after threading, UL listed, and meeting the requirements of UL 6 and ANSI C80.1.
   3. RNC shall be PVC Schedule 40 rigid plastic unless otherwise noted on the Drawings, shall be rated for use with 90 degree C wire, and shall conform to UL 651, WC-1094C and NEMA TC 2.
   4. Flexible (flex) conduit: Flex conduit is not approved and not acceptable. Where, in rare instances, flex conduit is the only remaining viable raceway option, the Contractor shall notify the Engineer and await the Engineer's direction prior to procurement and installation.
   5. Condulets (LB's): Condulets (LB's) are not approved and are not acceptable.

B. FITTINGS:
   1. Provide fittings as follows:
      a. EMT fittings shall be steel compression type with a nylon insulated throat for rain-tight and concrete-tight applications, steel set screw type or steel compression type for all other connections. Conduit ends shall be fitted with bushings – bushings shall be threaded type for RMC and IMC, set screw type for EMT, and have a nylon insulated throat.
      b. RMC fittings shall be threaded galvanized steel. Conduit ends shall be fitted with bushings – bushings shall be threaded and have a nylon insulated throat.
      c. RNC fittings shall be of same material and manufacturer as the conduit, shall be UL listed and conform to UL 514. Cement shall be as recommended by manufacturer.

2. Expansion fittings shall be provided across structural joints, shall be of a design to compensate for expansion and contraction, shall be sealed to prevent entrance of water and moisture, and shall safely deflect and expand up to twice the distance of the structural movement. Expansion fittings shall be approved for grounding duty.

2.3 INNERDUCTS (SUBDUCTS)

A. Innerducts: Provide in locations shown on Drawings.
   1. Inside Plant: Provide Innerduct(s) to enclose and protect all fiber optic cables between termination points within buildings. Innerducts shall be plenum or non-plenum rated to match that of associated cable and include a 2400 pound strength sequentially numbered pull tape, or equal. Innerducts shall be:
      a. Carlon: CF4X1C-xxxxx
   2. Outside Plant: Innerducts shall be corrugated and manufactured from High Density Polyethylene (HDPE), specifically manufactured for innerduct purposes. Innerducts shall be available in sizes from 1 inch through 2 inches, shall include a 2400 pound strength sequentially numbered pull tape (or equal), and shall include all fittings and connectors per manufacturer's recommendations. Innerducts shall be:
      a. Carlon: A5D2S1JNNxxxx

2.4 JUNCTION BOXES

A. Junction boxes shall be provided to serve as a transition point between pathways/raceways. Junction boxes shall be galvanized stamped steel, deep drawn one piece (without welds or tab connections), with knockouts for conduit entrances, meeting NEMA OS 1.

B. Junction boxes shall not be used to support Communications System equipment.

C. Junction boxes shall not be placed in walls or non-accessible ceiling locations unless specifically shown on the Communications Construction Drawings or approved in writing by the engineer prior to rough-in and installation.

D. Junction boxes in locations other than walls shall be sized according to the NEC.

E. Junction boxes in walls:
   1. Unless otherwise shown on the Drawings, junction boxes shall be minimum 4-11/16 inch by 4-11/16 inch by 2-1/8 inch deep with blank cover, and knockouts pre-manufactured to support the conduit size serving the junction box (i.e. field modifications of the junction boxes to support the conduit sizes specified are not acceptable).
   2. Size according to the NEC and provide the larger of the minimum size mentioned above or the NEC requirements.

2.5 DEVICE BOXES

A. General: Unless otherwise shown on the Drawings or specified herein, device boxes shall:
   1. Be galvanized stamped steel, deep drawn one piece (without welds or tab connections), with knockouts for conduit entrances, meeting NEMA OS 1, and equipped with extension rings to suit construction and application.
   2. Have knockouts pre-manufactured to support the conduit size serving the outlet box (i.e. field modifications of the outlet box to support the conduit sizes specified are not acceptable).

B. Device Box Types:
   1. Device Box: Typically installed as an empty box with blank faceplate, conduit and pull string for future use, unless specifically noted otherwise on the Communications Construction Drawings.
      a. Shall be a minimum 4-11/16 inch by 4-11/16 inch by 2-1/8 inch deep capable of accepting a minimum of (2) 1 inch conduits.
      b. Shall be equipped with a minimum single-gang mud ring unless otherwise noted on the Drawings.
         1) Mud ring depth shall be sized according to the depth of the wall surface per the Architectural Construction Documents.
      c. Provide a blank faceplate to match the material, style and color being used on the Electrical Wiring Devices.
   2. Outlet Box: Outlet boxes shall be provided to house Communications System equipment/outlets/connectors. Unless otherwise noted in the Communications (Technology) System Details on the Communications Construction Drawings the typical Outlet Box(es) shall be as follows:
      a. Communications Cabling System:
         1) Shall be a minimum 4-11/16 inch by 4-11/16 inch by 2-1/8 inch deep capable of accepting a minimum of (2) 1 inch conduits
         2) Shall be equipped with a single-gang mud ring unless otherwise noted on the Drawings or specified as follows:
            a) Mud ring depth shall be sized according to the depth of the wall surface per the Architectural Construction Documents.
            b) Wireless Access Point: Provide a cover plate in lieu of single-gang mud ring.
      b. Security:
         1) Refer to Communications (Technology) System Details on the Communications Construction Drawings and Manufacturers requirements. Coordinate with Security contractor prior to rough-in. Receive written directions as to device box requirements for each location.

2.6 PULL BOXES

A. Pull Boxes shall be code gauge sheet metal/fabricated steel continuously welded at seams and painted after fabrication. Boxes shall be complete with covers, trim, etc.

B. Minimum pull boxes sizes shall be as follows:

CONDUIT	PULL BOX SIZE WIDTH	LENGTH	DEPTH	FOR EACH ADDITIONAL CONDUIT INCREASE WIDTH
1”	4”	16”	3”	2”
1-¼”	6”	20”	3”	3”
1-½”	8”	27”	4”	4”
2”	8”	36”	4”	5”
2-1/2"	10"	42"	5"	6"
3"	12"	48"	5"	6"
3-1/2"	12"	54"	6"	6"
4"	15"	60"	8"	8"

C. Pull Boxes for conduits sized larger than shown in the table above shall be provided as shown on the Drawings.

2.7 FLOOR BOXES

A. Floor boxes shall provide the space required for power, communication and/or audio/visual cabling and interface devices at floor level. For slab-on-grade floors, the floor box must be suitable for installation in “on-grade” conditions. Floor boxes shall be flush style, shall exceed UL scrub water exclusion requirements for tile and carpet floors, and shall be complete with covers, brackets and hardware to support installation as shown on Drawings.
   1. Floor boxes may be combined for use by both power and communications where shown on the Drawings. When combined, provided metal dividers separating power from communications and provide separate conduits for power and communications.
   2. Floor boxes shall be complete with brackets, cover plates, and/or other means to support power, communications, and/or audio-visual type connectors shown on the Drawings or called for in the Specifications.

B. Floor Box Types:
   1. Single-Service Round Floor Box: Floor boxes shall be stamped steel, deep single-service. Covers shall accept a minimum of a 2-5/8” threaded opening.
   2. Raised Floor Shallow Floor Box (2-gang): Floor boxes shall be shallow.
   3. Shallow Floor Box (4-gang): Floor boxes shall be shallow.
   4. Floor Box (4-gang): Floor boxes shall be in a recessed box, shall be adjustable before concrete pour, and shall be complete with brackets to support power, communications, and/or audio/visual type connectors as shown on the Drawings and specified in Specifications.
   5. Deep Floor Box (8-gang): Floor boxes shall be in a recessed box, shall be adjustable before concrete pour, and shall be complete with brackets to support power, communications, and/or audio/visual type connectors as shown on the Drawings and specified in Specifications.

6. Floor Box (Flexible Conduit): Floor boxes shall be in a recessed box, shall be adjustable before concrete pour, and shall be complete with pans and brackets to support power, communications, and/or audio/visual type connectors as shown on the Drawings and specified in Specifications. Floor boxes shall be equipped with flexible conduit as required to interface into furniture. Floor boxes shall be approximately 7.5 inches x 7.38 inches by 3.5 inches deep, not including PVC riser. Pour pans shall be provided as required. Floor boxes shall be UL listed. Covers for floor boxes shall be included and shall support flexible conduit to furniture, as required. Covers shall be coordinated with Architect.

C. Floor Box Covers: Covers shall be provided for each floor box, shall support carpet/floor trim to match surrounding floor area, shall be UL listed to safety standards for tile, carpet and wood floor installation, and shall prevent water, dirt, and debris from entering power/communication/audio/visual outlets. Covers shall incorporate floor box manufacturer's protection to prevent water, dirt, and debris from entering the power and communication devices, and shall meet or exceed UL scrub water exclusion requirements for tile and carpet floors. Coordinate color with Architect and Owner. Cover type shall be:
   1. Cast aluminum

2.8 POKE-THROUGHS

A. Poke through devices shall provide the interface for power, communication and/or audio/visual cabling in an above grade floor and the workstation location where power, communication and/or audio/visual outlets are required. Poke-through assembly shall be flush style, shall exceed UL scrub water exclusion requirements for tile and carpet floors, and shall be complete with brackets and hardware to support installation as shown on Drawings.

B. Poke-throughs may be combined for use by both power and communications where shown on the Drawings. When combined, provided metal dividers separating power from communications and provide separate conduits for power and communications.

2.9 OTHER BOX TYPES AND REQUIREMENTS

A. Provide as required according to the Equipment Schedules, Notes and Communications Details on the Communications Construction Drawings.

PART 3 - EXECUTION

3.1 CONDUIT

A. General:
   1. Run conduit in the most direct route possible, parallel and perpendicular to building lines.
   2. Route conduits as close to structure as possible.
   3. Do not route conduit through areas in which flammable material may be stored, or over or adjacent to boilers, incinerators, hot water lines, or steam lines.
   4. Conceal all conduit unless indicated otherwise, within finished walls, ceilings, and floors.

5. Keep conduits at least 6-inches away from parallel runs of flues and steam or hot water pipes.
6. Install conduits level and square and at proper elevations.
7. For conduit runs exceeding more than 100 feet in length, provide pull boxes (see *Part 3 – Execution, Pull Boxes* herein) so that no conduit segment between end points/pull boxes exceeds 100 feet.
8. For conduit runs which require more than two 90 degree bends, install pull boxes (see *Part 3 – Execution, Pull Boxes* herein) so that no conduit segment between end points/pull boxes contains more than two 90 degree bends or a total of 180 degrees of bends including offsets and kicks.
9. Ream all conduits to eliminate sharp edges. Conduits shall be reamed after threads are cut.
10. Joints shall be cut square and shall butt solidly into couplings.
11. Terminate all metal conduits with metallic threaded insulated throat bushings, PVC conduit with PVC bushings.
12. Metallic conduits entering communication rooms shall be equipped with grounding lugs.
13. Prevent foreign matter from entering conduits by using temporary closure protection. After cable installation, cap each unused conduit with a mechanical-type seal (tape is not acceptable).
14. Conduits shall be installed in such a manner as to keep exposed threads to an absolute minimum and in no case shall more than three threads be left exposed.
15. Install expansion fittings where conduit crosses an expansion join in structure or is in an environment where temperature changes combined with conduit run length may produce expansion or contraction stress. Provide a flexible bonding jumper at least three times the nominal width of the joint.
16. Terminate conduits that protrude through a floor 1 to 3 inches above the surface of the floor.
17. Conduits shall be cleaned and dried prior to the installation of cables.
18. Route conduit through roof openings for piping and ductwork wherever possible. Where not possible, provide and route through roof jack with pitch pocket for waterproofing. Empty conduits passing through roof penetrations shall be capped and sealed weather tight.
19. Conduits passing through exterior walls and floors below grade shall be made watertight with duct plugs. Pipe sleeves and wall collars shall extend all around the conduit or entrance seals and be specifically manufactured for that purpose.
20. When using RNC, transition to RMC for all bends, stub-ups, and penetrations through foundation walls.

B. Conduit Schedule:
1. Buried or below grade level slab: RNC
2. Embedded in concrete slab: RNC
3. Through foundation walls: RMC
4. Corrosive/Hazardous Areas: RMC
5. Exposed or subject to mechanical injury: RMC
6. All other areas (unless otherwise noted): EMT

C. Minimum Conduit Sizing, where not shown on the Drawings,:
1. Junction Boxes in walls: 1 inch.
2. Device Boxes: 1 inch.
3. Pull Boxes: Provide per the Drawings.

4. Floor boxes: Provide per the Drawings. Where not shown, coordinate with the other Trades who will make use of the floor box and provide per their requirements. Conduits shall be provided per the manufacturer's requirements and recommendations for the specified floor box.
5. Poke-throughs: The size of the conduit feeding the poke-through shall be the same size as the conduit stub of the poke-through.

D. Conduit bends:
1. A conduit bend shall not exceed 90 degrees and shall not be constructed in such a way as to reduce the effective diameter of the conduit.
2. Conduit bends (other than bends in OSP Conduit Ductbank) shall be sweeping, shall conform to TIA 569 bend radius requirements, and shall be a minimum of no less than 6 times the internal diameter of the conduit for conduits 2-inches or less and a minimum of no less than 10 times the internal diameter of the conduit for conduits greater than 2-inches.
3. For conduits larger than 1-1/4 inch, bends shall be factory-manufactured. Bending conduit larger than this in the field using manual or mechanical methods is not acceptable. 1 inch and 1-1/4 inch bends shall be made in an approved bending machine or shall be factory-manufactured.
4. The contractor shall test each conduit with a mandrel to prove compliance with TIA and cable manufacturer bend radius requirements throughout the conduit run and shall provide evidence of such testing immediately upon request of the Engineer.
5. The sum total of conduit bends for a conduit segment between end points/pull boxes shall not exceed 180 degrees, except one additional bend of up to 90 degrees is acceptable if the bend is located within 12 inches of the cable feed end.
6. 90 degree condulets (LB's) are not acceptable.

E. Conduit Stubs:
1. From boxes in partition walls: Conduit stubs shall extend a minimum of 6-inches above top of partition wall and shall be angled 30 degrees toward the nearest raceway/pathway for horizontal cabling.
2. To cable tray: Terminate conduits 2 to 4 vertical inches above the tray and within 2 horizontal inches of the edge of the tray. Conduits shall not extend over the edge of the cable tray.
3. Through floor slabs: Arrange so curved portion of bend (if any) is not visible above finished slab.

F. Conduit/duct runs under slab: Coordinate with other trades (electrical, plumbing, etc.) prior to trenching and installation. Communications conduit/duct runs under slab shall not share a trench with conduit/duct runs from other trades.

G. Conduits embedded in slab: Not acceptable unless otherwise shown on the Drawings.

H. Pull String for horizontal and systems cable:
1. Equip all conduits over 3 feet long with plastic or nylon pull strings with printed footage indicators and a minimum test rating of 200 pounds. Extend pull string a minimum of 3 feet from each end. Pull strings shall be secured to avoid losing the pull string within the conduit by either securing tying the end of each string in place, or by tying the end of each string to a washer with a diameter larger than the conduit diameter.

2. Label each pull string in a clear manner by designating, at each end of the pull string, the location of the far end of the pull string (i.e. room name, communications closet name, pull box identifier, cable tray, station identifier, etc.). Indicate pull string length on the label.

I. Pull Ropes for backbone cable(Inside and Outside Plant):
1. Equip all conduits, over 3 feet long with 2400 pound test sequentially numbered pull tape, or equal. Where such conduits have innerducts, provide a 2400 pound test sequentially numbered pull tape (or equal) for each innerduct. Polyrope is not permitted. Pull rope shall be secured to avoid losing the pull rope within the conduit by either tying the end of each rope in place, or by tying the end of each rope to a washer with a diameter larger than the conduit diameter. Pull rope shall be exposed a minimum of 3 feet at the end of interior conduits and 10 feet at the end of exterior or underground conduits (ducts).
2. Label each pull rope in a clear manner by designating, at each end of the pull rope, the location of the far end of the pull rope (i.e. manhole name, communications closet name, pull box identifier, cable tray, etc.). Indicate pull rope length on the label.

J. Bushings: The Contractor is solely responsible for ensuring that bushings (insulated throat for metallic conduit, PVC for PVC conduit) are installed at conduit end(s) prior to cable installation. Where cable is installed prior to the installation of bushings, the Contractor shall remove the cable, install the bushing, and re-install the cable at no additional cost to the Owner.

K. Labels: Label each conduit end in a clear manner by designating, at each end of the conduit, the location of the far end of the conduit (i.e. room name, communications closet name, pull box identifier, cable tray, station identifier, etc.). Indicate conduit length on the label.

3.2 INNERDUCTS (SUBDUCTS)

A. Innerduct installation shall strictly comply with manufacturer's recommendations.

3.3 JUNCTION AND DEVICE BOXES

A. General:
1. Unless otherwise indicated, boxes shall be recessed. Set boxes plumb, level, square and flush with wall. Do not exceed more than 1/16 inch tolerance for each condition. Recess outside edge and trim plates from finished surface in accordance with NEC.
2. Boxes shall be supported independently of the conduit system. Supports shall be noncombustible and corrosion resistant. Suspended boxes shall be supported with threaded rod hangers and galvanized steel clamps, or trapeze hangers such as Unistrut.
3. Box locations may be adjusted by the Engineer by up to 10 feet from the location shown on the Drawings at no additional cost to the Owner.
4. Install additional straps or cross-bracing to ensure a rigid installation in a steel stud system.
5. Boxes on opposite sides of fire rated walls and partitions shall be separated by a horizontal distance of at least 24 inches.
6. Unused knockouts in boxes shall be left sealed.

7. For acoustical purposes, boxes on opposite sides of a wall shall not be located back-to-back.
8. For boxes to be installed in brick, masonry or concrete, offsets shall be provided to provide for proper adjustment to finished surfaces. Exposed mortar is not acceptable around device plates.
9. In the event of discrepancies between box locations shown on the Communications drawings and any other drawings in the Construction Documents, the Contractor shall notify the Engineer and await the Engineer's direction prior to installation.

B. Device Box Types
1. Device Box:
   a. Unless specifically noted otherwise on the Drawings, Device Boxes shall be dedicated to Communications Systems and shall not be shared with power.
   b. Provide with blank faceplate and pullstring.
2. Outlet Box:
   a. General:
      1) Unless specifically noted otherwise on the Drawings, Outlet Boxes shall be dedicated to Communications Systems, and shall not be shared with power.
      2) The contractor shall install the box and mudring such that the face of the mudring is flush with the face of the wall. Refer to the Architectural Construction Documents (Drawings and Specifications) for Wall Types, Materials and Installation Details.
      3) The use of dividers to divide a single box into "separate" sections for Communications Systems and power (or another function) is not acceptable.
   b. Communications Cabling System:
      1) Outlet boxes shall be located within 3 feet of an electrical power receptacle. Where conditions are such that this is not possible, promptly notify the Engineer and await the Engineer's direction prior to rough-in of the box.
   c. Security System(s):
      1) Refer to drawings and Manufacturers requirements.
      2) Coordinate with Security contractor prior to rough-in.
   d. AudioVisual System:
      1) Refer to drawings and Manufacturers requirements.
      2) Coordinate with AudioVisual contractor prior to rough-in.

3.4 PULL BOXES

A. Install pull boxes in an exposed location, readily accessible both at time of construction and after building occupation. Pull boxes shall not be installed in interstitial or otherwise non-accessible building spaces.

B. If mounting a pull box on ceiling structure above ceiling grid, do not mount higher than 4 feet above grid (mount on wall instead).

C. Install pull boxes such that conduit enters and exits only from opposite ends of the box (i.e. only two sides of a box may be used for conduit entry and those two sides must be opposite one another).

D. Do not install conduits into pullboxes in such a manner as to obstruct the installation of future feeder conduits into or out of the pullbox.

E. A pull box shall not be substituted for a 90 degree bend.

F. Do not exceed one pull box per total conduit run between outlet box and termination point in a communications closet, unless otherwise shown on the Drawings. Where field conditions necessitate the use of additional pull boxes notify the Engineer and await the Engineer's direction prior to procurement and installation.

G. Pull boxes shall be rigidly mounted. Unused knockouts shall be plugged with suitable blanking devices.

H. Labels: Label each pullbox with a unique identifier. Identifiers shall be of the form “RN-YY” where “RN” is the room name of the room closest to (or containing) the pull box, and “YY” is the sequential number of the pull box for each “RN”. For example: The second pull box in the vicinity of room “201” would have the label “201-02”.

3.5 FLOOR BOXES

A. Set boxes plumb, level, square and flush with floor. Do not exceed more than 1/16 inch tolerance for each condition.

B. Floor boxes shall have been tested for use in fire-resistance-rated assemblies applicable to the condition(s) present in Project, and shall be installed in accordance with the instructions included in the listing.

C. For floor boxes installed in concrete slab:
   1. Coordinate floor boxes with slab/concrete topping depth. Where depth of floor box conflicts with slab depth notify the Engineer and await the Engineer's direction prior to procurement and installation.
   2. Adjust box prior to and after concrete pour.

D. Covers shall be installed per manufacturer’s recommendations.

E. For floor boxes with combined power and communications circuits, install metal dividers for separation of circuits and provide separate conduits for power and communications.

3.6 POKE-THROUGHS

A. Poke-throughs shall be installed per manufacturer’s requirements and recommendations.

3.7 DISPLAY WALL BOXES

A. Set boxes plumb, level, square and flush with floor. Do not exceed more than 1/16 inch tolerance for each condition. Recess outside edge and trim plates from finished surface in accordance with NEC.

B. Boxes shall be supported independently of the conduit system. Supports shall be noncombustible and corrosion resistant. Suspended boxes shall be supported with threaded rod hangers and galvanized steel clamps, or trapeze hangers such as Unistrut.

C. Box locations may be adjusted by the Engineer by up to 10 feet from the location shown on the Drawings at no additional cost to the Owner.

D. Install additional straps or cross-bracing to ensure a rigid installation in a steel stud system.

E. Boxes on opposite sides of fire rated walls and partitions shall be separated by a horizontal distance of at least 24 inches.

F. Unused knockouts in boxes shall be left sealed.

G. For acoustical purposes, boxes on opposite sides of a wall shall not be located back-to-back.

H. For boxes to be installed in brick, masonry or concrete, offsets shall be provided to provide for proper adjustment to finished surfaces. Exposed mortar is not acceptable around device plates.

I. In the event of discrepancies between box locations shown on the Communications drawings and any other drawings in the Construction Documents, the Contractor shall notify the Engineer and await the Engineer's direction prior to installation.

J. Covers shall be installed per manufacturer's recommendations.

K. For wall boxes with combined power and communications circuits, install metal dividers for separation of circuits and provide separate conduits for power and communications.

END OF SECTION 270533

SECTION 270543 - ELECTRICAL TECHNOLOGY - UNDERGROUND DUCTS AND RACEWAYS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general requirements for the Underground Ducts and Raceways for the Communications System. General requirements are covered in Division 27 Specification Section *Electrical Technology – General Requirements*.

1.2 RELATED SECTIONS

A. The requirements of this Section are additional to, different from, or otherwise supplement the applicable requirements of Division 16. The applicable requirements of Division 16 shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

B. Division 27 Specification Section *Electrical Technology – Conduit and Boxes.*

1.3 REFERENCES

A. In addition to the Governing Requirements, the applicable portion of the following shall be incorporated by reference into this Section:
   1. Concrete:
      a. Reinforcement:
         1) ACI 301: Structural Concrete for Buildings
         2) ACI SP-66: American Concrete Institute - Detailing Manual
         3) ANSI/ASTM A82: Cold Drawn Steel Wire for Concrete Reinforcement
         4) ANSI/AWS D1.4: Structural Welding Code for Reinforcing Steel
         5) ANSI/AWS D12.1: Reinforcing Steel Welding Code
         6) ASTM A615: Deformed and Plain Billet Steel Bars for Concrete Reinforcement
         7) AWS D12: Welding Reinforcement Steel, Metal Inserts and Connections in Reinforced Concrete Construction
      b. Cast-in-Place:
         1) ACI 212.3R: Chemical Admixtures for Concrete
         2) ACI 301: Structural Concrete for Buildings
         3) ACI 304: Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete
         4) ACI 305R: Hot Weather Concreting
         5) ACI 306R: Cold Weather Concreting
         6) ASTM C33: Concrete Aggregates
         7) ASTM C39: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
         8) ASTM C94: Ready-Mixed Concrete

9) ASTM C150: Portland Cement
10) ASTM C143: Standard Test Method for Slump of Hydraulic Cement Concrete
11) ASTM C173: Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
12) ASTM C231: Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
13) ASTM C260: Air Entraining Admixtures for Concrete
14) ASTM C309: Standard Specifications for Liquid Membrane Forming Compound for Curing Concrete
15) ASTM C494: Chemical Admixtures for Concrete

c. Pre-Cast:
1) ASTM C478: Standard Specification for Precast Reinforced Concrete Manholes Sections
2) ASTM C857: Standard Practice for Minimum Structural Design Loading for Underground Precast Utility Structures
3) ASTM C858: Standard Specification for Underground Precast Concrete Utility Structures
4) ASTM C891: Standard Practice for Installation of Underground Precast Concrete Utility Structures
5) ASTM C1037: Standard Practice for Inspection of Underground Precast Concrete Utility Structures
6) ASTM D1751: Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)

2. Trenching and Backfill:
a. ASTM D1557: Test Method for Laboratory Compaction Characteristics Using Modified Effort

1.4 SUBMITTALS

A. Comply with the Submittal portion of Division 27 Specification Section *Basic Communications Requirements*. Provide submittal information for the following:
1. Product Data
2. Shop Drawings:
a. Raceway/pathway routing: Provide a raceway/pathway routing plan if such plan has not been shown on the Drawings, or if the Contractor is proposing a deviation from that shown.
1) If a routing plan is not required, submit written documentation stating that the routing will be provided as shown on the Drawings, that the Contractor has reviewed the routing shown on the Drawings with the other applicable trades and that all have agreed that it does not create conflicts between the trades, and the routing meets applicable codes, regulations and standards.

2) If a routing plan is required, submit complete site plans or detail drawings showing the proposed routing and raceway sizes and locations in a manner equal to that of the Drawings. Ensure that any routing changes are coordinated with comparable changes to the communications cable routing. Specifically note each location where the proposed routing is different from the Drawings. Where deviations are proposed, submit written documentation detailing the reason for each. Each deviation must be approved in writing by the Engineer prior to proceeding with installation.

1.5 DEFINITIONS

A. Aggregate: The mineral materials such as sand or stone used in making concrete

B. Backfill: Earth material used specifically for filling and grading excavations back to a finished state. Backfill is placed on top of the bedding surrounding encased ductbanks and direct-buried conduits.

C. Base: Earth material used specifically to level and grade an excavation's subgrade for the subsequent placement of encased ductbanks, direct-buried conduit, and UCVs. Base material is placed on top of the subgrade and beneath the bedding surrounding encased ductbanks, conduits, or UCVs.

D. Bedding: Earth material used specifically for filling excavations. Bedding is placed around encased ductbank, conduits, or UCVs. Bedding is placed on top of the base and beneath the backfill.

E. Fill: The collective term for base, bedding, and backfill.

F. Handhole: A small UCV in which it is expected that a person cannot enter to perform work. Handholes are primarily used for the placement of cable, but are also occasionally used for splicing or for equipment.

G. Maintenance hole: A large UCV in which it is expected that a person can enter to perform work. Maintenance holes may be used for splicing and outside-rated telecommunications equipment.

H. Pullbox: A small UCV in which it is expected that a person cannot enter to perform work. Pullboxes are used for the placement of cable only; they are not used for splicing or for equipment.

I. Underground Cable Vault (UCV): Underground vaults (maintenance holes, handholes, or pullholes) which are used for the routing of communications cable.

J. Vault: See Underground Cable Vault (UCV).

PART 2 - MATERIALS

2.1 GENERAL

A. Materials shall consist of fill, topsoil, concrete formwork, concrete, raceway, UCVs, and other incidentals and accessories as required.

2.2 BASE, BEDDING AND BACKFILL

A. Base: Base material shall have size and shape characteristics that will allow it to compact readily and shall conform to the following gradation requirements.

For Trenches (provide sand):

Sieve Size	Percent Passing
U.S. No. 10	35 - 100
U.S. No. 20	20 - 80
U.S. No. 40	10 – 55
U.S. No. 100	0 – 10
U.S. No. 200	0 - 3

B. Bedding: Same as Base - For Trenches, above.

C. Backfill:

For Trenches

Sieve Size	Percent Passing
½-inch Square	100
¼-inch Square	65 – 100
U.S. No. 10	40 – 100
U.S. No. 50	3 – 50
U.S. No. 100	0 – 4
U.S. No. 200	0 - 3

2.3 CAST-IN-PLACE CONCRETE

A. Formwork:

1. Forms: Forms shall be metal or plywood in good condition. Gypsum board may be used only for the formation of concrete encased ductbank. The Contractor will be allowed to use the most advantageous panel sizes and panel joint locations. Neat patches and minor surface imperfections will be permitted. Surfaces formed shall be true planes within ¼-inch in 10-feet.
2. Form Release Agent: Where metal or plywood forms are used the forms shall be coated with a form release agent prior to placement of concrete. Except for gypsum board, faces and edges of forms shall be coated with Burke Form Coating (or equal) applied at a rate of 500 to 550 square feet per unit. Gypsum board form material may be left in place for concrete encased ductbank after concrete placement and need not be coated with form release agent.

3. Curved Surfaces: Only curved forms shall be used for constructing curved structures and surfaces. If gypsum board is used for concrete encased ductbank, gypsum board may be used for curves provided that a minimum 15 foot bend radius is maintained.

B. Reinforcement:
1. Reinforcing Steel: Reinforcing Steel shall conform to ASTM A615, Grade 40. Steel shall be uncoated, free from rust, dirt, and loose scale.
2. Tie Wire: Tie wire shall be 18 gauge 40 or heavier black annealed wire.
3. Embedded Anchor Bolts: Embedded anchor bolts shall be mild galvanized steel, cold bent.

C. Concrete:
1. Cement: Different types of cement, including the same type of cement provided by more than one manufacturer, are not acceptable: Cement shall conform to:
   a. ASTM C150-7, type 1.
   b. Minimum compressive strength shall be 3,000 psi at 28 days per ASTM C39.
   c. Maximum slump shall be 4 inches per ASTM C-143.
2. Aggregate: Aggregate shall conform to:
   a. Course: ASTM C33-71 with a maximum size of 1-¼ inches.
   b. Fine: ASTM C33-71.
3. Water: Water shall be fresh, clean, potable and not detrimental to concrete.
4. Admixtures:
   a. Air Entrainment: Conform to ASTM C260 and ASTM C173 or C231 with 5 percent to 7 percent air entrainment.
   b. Other: Other admixtures shall not be used without prior approval.
5. Curing Compound: Curing compound shall conform to ASTM C309 and shall be free from petroleum resins or waxes. Sealer-hardener formulated for sealing, surface hardening, and curing concrete shall be utilized. Curing method and rate of application shall be according to manufacturers recommendations.

2.4 DUCTS AND DUCTBANKS

A. Ducts: Provide in locations as shown on the drawings. Refer to Part - 3, Execution for details on when to use each type. All conduit, fittings, and adhesives shall be provided by the same manufacturer.
1. Types:
   a. RNC – Rigid Non-Metallic Conduit (PVC):
      1) Schedule 40 or 80:
         a) RNC, unless otherwise noted, shall be NEMA TC 2 or TC 6 schedule 40 or 80 (see Part - 3, Execution for details on when to use each type) rigid polyvinyl chloride (PVC) approved for direct burial without concrete encasement. RNC shall be UL listed.
         b) Fittings shall be NEMA TC 3 or TC 9, matched to conduit and material.
   b. RGC – Rigid Galvanized Steel Conduit:
      1) RGC shall be rigid steel conduit hot-dipped galvanized inside and out with threaded ends meeting ANSI C80.1.

2) Couplings: Unsplit, NPT threaded with galvanizing equal to and compatible with conduit. Running thread or set screw threaded fittings (except for three piece and watertight split couplings) are not acceptable.
3) Nipples: Factory made through eight-inches with no running threads.

c. PSC – PVC Coated Rigid Steel Conduit:
1) PSC shall be NEMA RN 1 rigid steel conduit coated with rigid polyvinyl chloride (PVC) on exterior.
2) Fittings shall be NEMA RN 1.

2. Fittings:
a. Bends/Sweeps:
1) Bends/sweeps shall be factory manufactured.
2) Bends shall consist of a single arc of not less than a 15 foot radius. Where this is not possible due to existing site conditions, a bend radius shall not be less than 10 times the internal diameter of the conduit.
3) Bends not less than 10 times the internal diameter of the conduit are acceptable at locations where duct/ductbank is stubbing vertically up into the floor of the building.
4) The use of 90 degree elbows, LB's, condulets, or the use of a UCV in place of a bend/sweep is not acceptable.

b. End Caps (Plugs): Provide pre-manufactured water-tight end caps for all ducts during construction. Tape is not an acceptable end cap or cover.

c. Duct plugs: Provide duct plugs for sealing around, organizing, and supporting innerducts and cables. Duct plugs shall provide a long-term airtight and watertight seal. Manufacturer shall be:
1) Jack Moon/Tyco (various sizes)

d. End Bells: Provide end bells for terminating conduit in UCVs. Do not provide for conduit ends terminating in UCVs which are equipped with TERM-A-DUCT.

3. Pull Ropes: Provide a 2400 pound strength sequentially numbered pull tape, or equal, in each duct and innerduct. Polyrope is not permitted.

B. Ductbanks:
1. Unless otherwise noted on the Drawings, ductbanks shall consist of concrete encased RNC (see CAST-IN-PLACE CONCRETE, above).
2. Duct Spacers/Supports: Provide high-density plastic interlocking spacers/supports to maintain uniformity of multiple ducts within a ductbank. Spacers shall be:
a. CARLON ELECTRICAL PRODUCTS: SNAP-LOC Series.
3. Warning Tape: Provide metallic warning tape above each ductbank. Tape shall be 6-inches wide and orange in color.
4. Grounding/Bonding: Provide a continuous (non-spliced) #2 bare ground along length of ductbank.
5. Refer to the Telecom Ductbank Details (TE-CEDB and/or TE-SEDB) in the Communications Systems Construction Drawings for additional material requirements.

2.5 LANDSCAPING
1. Topsoil: Topsoil shall be imported and used for all excavations in grass and landscaped areas.

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section *Basic Communications Requirements*.
   1. Governing Requirements of particular relevance to this Section include, but are not limited to:
      a. TIA - 758: Customer-owned Outside Plant Telecommunications Cabling Standard
      b. TIA - 568: Commercial Building Telecommunications Cabling Standard
      c. TIA - 569: Commercial Building Standard for Telecommunication Pathways and Spaces
      d. TIA - 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
      e. TIA - 607: Commercial Building Grounding and Bonding Requirements for Telecommunications
      f. BICSI: Customer Owned Outside Plant Design Manual
      g. BICSI: Telecommunications Distribution Methods Manual
      h. BICSI: BICSI Telecommunications Cabling Installation Manual

3.2 EXCAVATING, TRENCHING AND FILL

A. Excavation:
   1. Excavations shall not be performed where the outside temperature is less than 35 degrees Fahrenheit or when there is standing water or snow on the subgrade.
   2. Excavations requiring crossing of concrete or asphalt shall be performed only after the surface material has been saw cut and removed. Concrete shall be removed in complete sections from control joint to control joint regardless of the width of the excavation. Concrete and asphalt shall be replaced to match existing depth, strength, color, and type of material.
   3. Adjacent structures which may be compromised or damaged by excavation work shall be underpinned as evaluated and recommended by a registered structural engineer employed by the Contractor prior to proceeding with the work.
   4. The Contractor shall maintain adequate separation between the excavation and adjacent underground utilities. The excavation shall be located such that ductbank and UCVs, when installed, shall have a minimum separation of three inches of well tamped dirt between concrete encased ductbanks and UCV and the nearest underground utility. This minimum separation shall increase to twelve inches for direct buried ductbanks. For gas lines a minimum separation of eighteen inches is required for concrete encased or direct buried ductbanks. For water a minimum separation of thirty-six inches is required for concrete encased or direct buried ductbanks.
   5. Communications conduit/duct runs under slab shall not share a trench with conduit/duct runs from other trades.
   6. Excavations shall not be left unprotected at the end of the work shift. Excavations shall be covered with steel sheets and barricaded prior to leaving the job site, in accordance with all applicable rules, regulations, building codes, and ordinances.

7. The Contractor shall not allow water to accumulate in excavations. The Contractor shall install, operate and maintain all pump or dewatering equipment necessary to meet this requirement.
8. Depth of excavation
    a. For UCVs: Depth shall allow for the overall assembled height of the vault plus the added height of risers, covers and bedding material consisting of a minimum six to twelve inches of base. Width of excavation for UCVs shall provide for a minimum of six (6)-inches clearance around each side of the UCV.
    b. For trenches: Depth shall be sufficient to cover a minimum of twenty-four inches (36 inches wherever possible) over the conduit or ductbank formation. Width of excavation for trenches shall be a minimum of six inches to each side of the ductbank formation. Depth of excavation for trenches shall allow for the proper alignment of ducts into UCVs.
9. Soft spots in the subgrade shall be over-excavated, filled, and compacted.
10. Excavation for trenching shall run true and as straight as practicable. Trenches shall be clear of stones and soft spots.
11. Trench grade shall be sloped to fall 3-inches per 100 feet in general and ¼ inch per foot where possible.
    a. Slope shall fall toward lower UCVs or from high points toward both UCVs.
    b. Slope shall always fall away from building entrances.

B. Fill:
1. Prior to the placement of fill, all groundwater and surface water shall be drained or pumped from the recipient area.
2. Frozen fill shall not be placed.
3. Base:
    a. The subgrade bed to receive fill shall be scarified and moisture conditioned prior to placing materials.
    b. Base material shall be moisture conditioned to within three percent of optimum moisture content and shall be placed in loose, horizontal layers.
    c. The subgrade bed shall be leveled using sand for trenches and gravel for UCVs as necessary to form an even base.
4. Bedding:
    a. For concrete encased ductbank:
        1) Bedding lifts/layers shall not exceed 4-inches before compaction.
    b. For Direct-buried Ductbank:
        1) Lifts/layers shall not exceed 1 to 2 inches before compaction until the top of the ductbank is reached and shall not exceed 4 inches thereafter. Bedding shall be placed simultaneously on both sides of ductbank for the full width of the trench. The materials shall be carefully worked above, to each side, and below the ducts with a tool capable of preventing the formation of void spaces and without damaging the structure or waterproofing of the ducts.
5. Backfill:
    a. Backfill lifts/layers shall not exceed 6 inches before compaction.
6. Compaction: Compaction shall be performed using a vibratory plate or roller or other mechanical device. Compaction through jetting or ponding is not acceptable. Compact per APWA Standard Specification Paragraph 7-10.3 (11).
    a. Bedding: Material shall be compacted to a dense state equaling at least 95 percent of the maximum dry density per ASTM D1557.

b. Backfill: Material shall be compacted to within two (2)-feet of the finished surface with a minimum relative compaction of 90 percent of the maximum dry density per ASTM D1557. Material within two (2)-feet of the finished surface shall be compacted with a minimum relative compaction of 95 percent of the maximum dry density per ASTM D1557.

C. Waste Disposal: The Contractor shall remove all excavation materials and other construction debris from the site in a timely manner. Materials shall be disposed of legally.

3.3 CAST-IN-PLACE CONCRETE

A. Concrete shall be constructed in accordance with the applicable portions of the specifications, standards, codes and regulations (latest editions and amendments) listed in Section 1, References.

B. The Contractor shall submit a copy of the delivery receipt for each concrete delivery which shall include date, strength ordered, and location used.

C. Formwork:
1. Construction:
   a. Forms: Forms shall be fabricated to provide minimum three inches of concrete between ducts and surrounding backfill. Forms shall be cleaned and free of debris prior to pouring concrete. Braces shall be unyielding and tight to prevent leakage. Maintain formwork construction tolerances complying with ACI 347. Formwork shall be readily removable without impact, shock, or damage to concrete surfaces and adjacent materials. Use chamfer strips fabricated to produce uniform smooth lines and tight edge joints for all exposed corners and edges. Note: chamfer strips are not required for concrete encased ductbank corners and edges.
   b. Reinforcement: Reinforcement shall be constructed in accordance with ACI SP-6. Weld reinforcement in accordance with ANSI/AWS D1.4 or ANSI/AWS D12.1. Accurately position, support, and secure reinforcement against displacement. Support reinforcement by metal/plastic chairs, runners, bolsters, spacers, hangers, or other incidental materials as required.
2. Slope: For flatwork, forms shall be constructed with 1 percent side slope to both south and east sides.
3. Joints:
   a. Control: Shall be built into form.
   b. Expansion: Expansion joints shall be built into form, shall be premolded ½ inch thick, and shall conform to ASTM D1751. Top ½ inch of expansion joints shall be sealed with an approved joint sealer.
4. Removal: Remove forms after concrete has cured (see Curing below) for 7 days or after concrete has attained a compressive strength of 2000 psi. If gypsum board forms are used to form concrete encased ductbank they can be left in place and backfilled after the specified curing period.

D. Concrete:
1. Transport: Contractor shall comply with ACI 304. Concrete shall be transported from the mixer to the construction location via methods preventing separation of materials.

2. Application:
    a. Prior to placement, inspect and complete formwork construction, reinforcement, and items to be embedded or cast-in.
    b. Deposit concrete in forms in layers not deeper than 24 inches and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer on the preceding layer while the preceding layer is still plastic. Cold joints are not acceptable.
    c. Concrete shall be deposited in a plastic condition and shall be uniformly worked around reinforcements.
    d. Concrete shall be consolidate by internal machine vibration (stinger) during pouring.
    e. Once concrete work has commenced, work shall be continuous until the work segment or section has been completed.
    f. Cold Weather: Concrete shall be protected from damage caused by frost, freezing, or low temperatures in compliance with ACI 306R. When temperature is below 40 degrees F, water and aggregates shall be heated before mixing to obtain a concrete mixture of not less than 50 degrees F and not more than 80 degrees F.
    g. Hot Weather: Concrete shall be protected from damage caused by hot weather in compliance with ACI 305R. When temperature is above 90 degrees F water shall be chilled before mixing to obtain a concrete mixture of not more than 90 degrees F. Cover reinforcing steel with water-soaked burlap if it becomes too hot immediately before placement of concrete. Temperature of steel shall not exceed the ambient air temperature.
3. Curing:
    a. Concrete shall be protected from premature drying, rain, excessive temperatures, and mechanical injury during the curing period.
    b. Concrete shall be cured for 7 days in accordance with ACI 301 and shall be kept continuously moist during this time. Concrete temperature shall be strictly maintained between 50 degrees and 90 degrees F during the curing period.
    c. Provide curing and sealing compound to exposed slabs, sidewalks, curbs, etc. as soon as final finishing operations are complete (within 2 hours). Re-coat areas subjected to heavy rainfall within 3 hours of the initial application.
4. Finish:
    a. Surfaces shall be consolidated, leveled and screened for evenness and uniformity. All excess concrete shall be removed. Low spots shall be filled. Surface shall be floated after water sheen has disappeared from surface.
    b. Flatwork shall be finished with a special tool to match patterned finish of adjacent existing concrete.
    c. Finish work shall be straight and even with tooled edges, control, and expansion joints.
5. Ductbanks:
    a. Ductbanks shall have full length reinforcement with formed sides. Reinforcement shall be installed at each corner of the duct spacers/supports.
    b. Concrete shall not be poured against trench walls. Concrete shall be consolidated during placement by an internal concrete vibrator.
    c. Each UCV penetration shall be provided with reinforcing bars tied to UCV reinforcement. Each building penetration shall have reinforcement doweled into foundation wall at building entry.
    d. Secure duct spacers/supports and reinforcing to prevent movement during concrete placement.

6. Protection for exposed concrete: Exposed concrete (i.e. sidewalk, driveway, etc.) shall be covered with plywood which is weighted with concrete blocks or similar heavy object in order to prevent surface damage.
7. Reinforcement bars shall be bonded and grounded to the nearest approved ground

3.4 DUCTS AND DUCTBANK

A. Ducts:
1. The type of duct to use shall be dictated by the application:
   a. Outdoor underground – sand encased or direct buried: Provide RNC Schedule 80 or PSC.
      1) Transition to PSC at stub up locations and at entrances to buildings.
      2) Transition to PSC or RGC for short radius bends (i.e. bends with less than 15-foot radii sweeps).
   b. Outdoor underground – concrete encased: Unless specified otherwise, provide RNC Schedule 40.
      1) Transition to PSC at stub up locations and at entrances to buildings.
   c. Exposed or within 5 feet of steam lines or Utilidor trenches: Provide RGC.
2. Fittings:
   a. Duct ends shall be cut square and reamed to remove burrs and sharp ends. Duct shall extend the maximum distance into all fittings, couplings, and connectors. All fittings shall be tightened securely and sealed watertight (see below).
   b. Bends/Sweeps:
      1) Bends shall consist of a single arc of not less than a 15 foot radius. Where this is not possible, a bend radius shall not be less than 10 times the internal diameter of the conduit. Short radius bends (45 and 90 degrees) are not permissible.
         a) Bends not less than 10 times the internal diameter of the conduit are acceptable at locations where duct/ductbank is stubbing vertically up into the floor of the building.
      2) An individual bend shall not exceed 90 degrees.
      3) A duct section may have no more than the equivalent of two 90 degree bends (a total of 180 degrees) between pull points. The 180 degree maximum shall include kicks and offsets. Where it is not possible to construct a section of duct within the 180 degree bend maximum, intermediary UCVs must be installed.
      4) Two 90 degree bends separated by less than 10 feet is not permissible.
      5) Bends for ducts within a common ductbank shall be parallel, measured from the same center-point.
      6) Where factory manufactured bends cannot be obtained due to a unique bend radius, bends shall be formed only with factory recommended equipment and shall be manufactured in such a way as to ensure that the internal diameter of the duct is not changed.
   c. End Caps (Plugs): End caps shall be placed on all duct ends throughout construction in order to prevent the intrusion of water or debris. End caps shall be installed on all duct that is not directly being worked on during the work day and on all ducts at night. End caps shall be left in place upon final completion of the work.

d. End Bells: For UCVs which are not equipped with TERM-A-DUCT, install protective end bells on ducts flush with UCV wall.

3. Sealing: Duct connections shall be made waterproof and rustproof by application of a watertight, conductive thread compound (for RGC and PSC) or by solvent-type cement (for RNC). Duct terminations in UCVs shall be sealed and grouted (to ensure that all voids in the joints are filled). Duct terminations in buildings shall be sealed/watertight until used for cable.

4. Test Mandrels:Each duct, once installed, shall be cleaned of debris with a wire brush or swab and shall be proven out with a minimum 16 inch long test mandrel which is ¼ inch smaller than the inside diameter of the duct. Test mandrel shall be pulled after backfilling but prior to the replacement of landscaping. The Contractor shall repair any duct that does not prove out at no cost to the Owner.
   a. Duct shall be cleaned a minimum of two times in the same direction and swabbed with clean rags until the rag comes out of the conduit clean and dry. Swab away from buildings for duct sections connected to buildings.

5. Duct Entrances:
   a. UCV's:
      1) Duct entrances at opposite ends of a UCV shall be at the same level and in the same position with respect to the side walls. The Contractor shall ensure that each duct leaving a UCV in any position shall enter the next UCV in the same relative position.
      2) UCVs shall not be drilled or penetrated without written Owner permission.
   b. Buildings: Ducts shall terminate 4-inches above the finished floor.

6. Length: Unless otherwise shown on the Drawings, the maximum length of a duct run shall not exceed 500 feet between UCVs or pulling points. Install additional UCVs as required to maintain spacing.

7. Pull Ropes (pull tape, or equal): Install in each duct immediately after the duct has been cleaned and mandreled. Install a pull rope in each innerduct in lieu of the duct for such situations. Pull rope shall be without knots or splices. Leave a minimum of 10 feet looped and tied off at each end of the duct.

8. Protection: Insure that after installation all duct coatings and finishes are without damage. Repair as follows:
   a. PVC Coated Rigid Steel Conduit: Patch all nicks and scrapes in PVC coating after installing conduits.
   b. Rigid Galvanized Steel Conduit: Repair damage to galvanized finishes with zinc-rich paint as recommended by the manufacturer.
   c. Rigid Non-metallic Conduit: Repair damage with matching touchup coating recommended by the manufacturer.

B. Ductbanks:
   1. Refer to the Telecom Ductbank Details (TE-CEDB and/or TE-SEDB) in the Communications Systems Construction Drawings for additional installation requirements.
   2. Encased in Sand:
      a. Warning Tape: Install metallic warning tape six inches below grade.
      b. Grounding/Bonding: Install ground wire along length of ductbank. Bond to grounding electrodes of UCV's and to building service grounds.
      c. Ductbank slope shall be such that ducts will drain away from building entrances (i.e. slope away from buildings).

3. Encased in Concrete:
   a. See CAST-IN-PLACE CONCRETE, above.
4. Duct Spacers/Supports: Supports shall be spaced on eight (8) foot centers if encased in concrete and five foot centers otherwise. Spacers shall be interlocked horizontally only. Spacers encased in concrete shall be staggered at least six inches vertically.
5. Warning Tape: Install metallic warning tape six inches below grade.
6. Grounding/Bonding: Install ground wire along length of ductbank. Bond to grounding electrodes of UCV's and to building service grounds.
7. Ductbank slope shall be such that ducts will drain away from building entrances (i.e. slope away from buildings).

3.5 LANDSCAPING

A. The Owner will seed and maintain grass areas disturbed by construction activity. Shrubbery damaged, removed or disturbed by construction activity will be replaced by the Owner.

B. Topsoil: Provide loosely compacted topsoil to a depth of 4 inches or depth of excavation for excavations less than 12 inches. Place imported topsoil for all excavations in turfed or landscaped areas. Restore existing grades where disturbed. Topsoil, once properly placed, shall be raked and smoothed. Installation shall be acceptable for landscaping by Owner. Place topsoil per APWA Paragraph 8-01.3(2).

END OF SECTION 270543

SECTION 270545 - ELECTRICAL TECHNOLOGY - MAINTENANCE AND HAND HOLES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general requirements for the Maintenance and Hand Holes (Underground Cable Vaults) for the Communications System. General requirements are covered in Division 27 Specification Section *Electrical Technology – General Requirements*.

1.2 RELATED SECTIONS

A. The requirements of this Section are additional to, different from, or otherwise supplement the applicable requirements of Division 26. The applicable requirements of Division 26 shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

B. The requirements of this Section are additional to, different from, or otherwise supplement the applicable requirements of Specification Section *Electrical Technology – Underground Ducts and Raceways*. The applicable requirements of Specification Section *Electrical Technology – Underground Ducts and Raceways* shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 REFERENCES

A. In addition to the Governing Requirements, the applicable portion of the following shall be incorporated by reference into this Section:

1. Concrete:

a. Pre-Cast:

1) ASTM C857: Standard Practice for Minimum Structural Design Loading for Underground Precast Utility Structures
2) ASTM C858: Standard Specification for Underground Precast Concrete Utility Structures
3) ASTM C891: Standard Practice for Installation of Underground Precast Concrete Utility Structures
4) ASTM C1037: Standard Practice for Inspection of Underground Precast Concrete Utility Structures
5) ASTM D1751: Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)

2. Trenching and Backfill:

a. ASTM D1557: Test Method for Laboratory Compaction Characteristics Using Modified Effort

1.4 SUBMITTALS

A. Comply with the Submittal portion of Division 27 Specification Section *Basic Communications Requirements*. Provide submittal information for the following:

1. Product Data
2. Shop Drawings:

a. UCV location: Provide a UCV location plan if such plan has not been shown on the Drawings, or if the Contractor is proposing a deviation from that shown.

1.5 DEFINITIONS

A. Aggregate: The mineral materials such as sand or stone used in making concrete

B. Backfill: Earth material used specifically for filling and grading excavations back to a finished state. Backfill is placed on top of the bedding surrounding encased ductbanks and direct-buried conduits.

C. Base: Earth material used specifically to level and grade an excavation's subgrade for the subsequent placement of encased ductbanks, direct-buried conduit, and UCVs. Base material is placed on top of the subgrade and beneath the bedding surrounding encased ductbanks, conduits, or UCVs.

D. Bedding: Earth material used specifically for filling excavations. Bedding is placed around encased ductbank, conduits, or UCVs. Bedding is placed on top of the base and beneath the backfill.

E. Fill: The collective term for base, bedding, and backfill.

F. Handhole: A small UCV in which it is expected that a person cannot enter to perform work. Handholes are primarily used for the placement of cable, but are also occasionally used for splicing or for equipment.

G. Maintenance hole: A large UCV in which it is expected that a person can enter to perform work. Maintenance holes may be used for splicing and outside-rated telecommunications equipment.

H. Pullbox: A small UCV in which it is expected that a person cannot enter to perform work. Pullboxes are used for the placement of cable only; they are not used for splicing or for equipment.

I. Underground Cable Vault (UCV): Underground vaults (maintenance holes, handholes, or pullbox(es) which are used for the routing of communications cable.

J. Vault: See Underground Cable Vault (UCV).

PART 2 - MATERIALS

2.1 GENERAL

A. Part Numbers: Refer to the Equipment Schedule(s) on the Communications Construction Drawings for specific manufacturers and part numbers. If no part number is provided, then any part meeting the manufacturer and requirements specified is acceptable.

B. Other materials shall consist of fill, topsoil, UCVs, and other incidentals and accessories as required.

2.2 BASE, BEDDING AND BACKFILL

A. Base: Base material shall have size and shape characteristics that will allow it to compact readily and shall conform to the following gradation requirements.
   1. For UCVs (provide gravel):

Sieve Size	Percent Passing
1 inch Square	100
¼ inch Square	25 – 80
U.S. No. 200	15.0 max
Sand Equivalent	30 min

B. Backfill:
   1. For UCVs - Same as Base - For UCVs, above.

2.3 UNDERGROUND CABLE VAULTS (UCVS)

A. Manufacturer: UCVs shall be precast in an established precast yard. Precast components shall conform to the requirements of ASTM C858 and other ASTM standards and specifications as listed in References, above. Precast UCVs shall be free from damaged joint surfaces, cracks, or other damage that would permit infiltration. Precast concrete structures may be repaired; repairs shall be performed only by the manufacturer in such a manner as to ensure that the repaired structure conforms to the requirements of this Specification and ASSTM C858. UCVs and incidental and miscellaneous equipment (such as cable racking brackets and supports) shall be supplied by a single manufacturer and shall be manufactured by:
   1. Oldcastle Precast (no substitutions)
      a. Formerly Amcor Precast

B. UCVs:
   1. Handholes: Handholes shall be provided in the locations and sizes shown on the Drawings.

a. Sizes and Types:
   1) 3'-1" W by 6'-7" L by 4'-0" H (exterior dimensions). Handhole shall be complete with galvanized hatch (see below), Base Section, section gaskets, and two galvanized pulling iron per longitudinal side (four total). Handhole shall be provided with one galvanized "C" channel per longitudinal side.
b. Covers and Frames: Covers shall be rectangular, equipped with a self latching galvanized cover with steel tread plate and galvanized steel slam lock, recessed lift inserts, lock down bolts, shall be embossed in the lid casting with minimum 2 inch high letters stating "COMMUNICATIONS", shall be of and shall conform to AASHTO HS-20 loading (incidental traffic). Frames shall be galvanized and adjustable.
c. Racking and Hardware: Provide two cable racks per longitudinal side (four racks total) per handhole. Provide four 7-½ inch cable support arms per handhole. Provide all incidental hardware for mounting racks and cable support arms.

2. Pullbox: Pullboxes shall be provided in the locations and sizes shown on the Drawings.
   a. Size and Type:
      1) 2'-3" W by 5'-2½" L by 2'6" H (exterior dimensions). Pullbox shall be complete with Cover Section, Base Section, section gaskets, and one galvanized pulling iron per longitudinal side (two total).
   b. Covers and Frames:
      1) Covers shall be of the same nominal length and width as the pullbox, shall be equipped with self latching galvanized steel slam locks, recessed lift inserts, lock down bolts, shall be embossed in the lid casting with minimum 2 inch high letters stating "COMMUNICATIONS", and shall conform to AASHTO HS-20 loading (incidental traffic).
   c. Racking and Hardware: Provide one cable rack per longitudinal side (two racks total) per pullbox. Provide two 7-½" cable support arms per pullbox. Provide all incidental hardware for mounting racks and cable support arms.

C. Grounding: UCVs (with the exception of small pullboxes) shall be complete with a minimum of one ¾ inch by 10 foot copperclad steel ground rods, and one #6 (minimum) pigtail for connection to interior ground conductors.

2.4 LANDSCAPING

1. Topsoil: Topsoil shall be imported and used for all excavations in grass and landscaped areas.

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section *Basic Communications Requirements*.
   1. Governing Requirements of particular relevance to this Section include, but are not limited to:
      a. TIA - 758: Customer-owned Outside Plant Telecommunications Cabling Standard
      b. TIA - 568: Commercial Building Telecommunications Cabling Standard

c. TIA - 569: Commercial Building Standard for Telecommunication Pathways and Spaces
d. TIA - 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
e. TIA - 607: Commercial Building Grounding and Bonding Requirements for Telecommunications
f. BICSI: Customer Owned Outside Plant Design Manual
g. BICSI: Telecommunications Distribution Methods Manual
h. BICSI: BICSI Telecommunications Cabling Installation Manual

3.2 EXCAVATING, TRENCHING AND FILL

A. Excavation:
1. Excavations shall not be performed where the outside temperature is less than 35 degrees Fahrenheit or when there is standing water or snow on the subgrade.
2. Excavations requiring crossing of concrete or asphalt shall be performed only after the surface material has been saw cut and removed. Concrete shall be removed in complete sections from control joint to control joint regardless of the width of the excavation. Concrete and asphalt shall be replaced to match existing depth, strength, color, and type of material.
3. Adjacent structures which may be compromised or damaged by excavation work shall be underpinned as evaluated and recommended by a registered structural engineer employed by the contractor prior to proceeding with the work.
4. The Contractor shall maintain adequate separation between the excavation and adjacent underground utilities. The excavation shall be located such that ductbank and UCVs, when installed, shall have a minimum separation of three inches of well tamped dirt between concrete encased ductbanks and UCV and the nearest underground utility. This minimum separation shall increase to twelve inches for direct buried ductbanks. For gas lines a minimum separation of eighteen inches is required for concrete encased or direct buried ductbanks. For water a minimum separation of thirty-six inches is required for concrete encased or direct buried ductbanks.
5. Communications conduit/duct runs under slab shall not share a trench with conduit/duct runs from other trades.
6. Excavations shall not be left unprotected at the end of the work shift. Excavations shall be covered with steel sheets and barricaded prior to leaving the job site, in accordance with all applicable rules, regulations, building codes, and ordinances.
7. The Contractor shall not allow water to accumulate in excavations. The Contractor shall install, operate and maintain all pump or dewatering equipment necessary to meet this requirement.
8. Depth of excavation
   a. For UCVs: Depth shall allow for the overall assembled height of the vault plus the added height of risers, covers and bedding material consisting of a minimum six to twelve inches of base. Width of excavation for UCVs shall provide for a minimum of six inches clearance around each side of the UCV.
   b. For trenches: Depth shall be sufficient to cover a minimum of 24 inches (36 inches wherever possible) over the conduit or ductbank formation. Width of excavation for trenches shall be a minimum of six inches to each side of the ductbank formation. Depth of excavation for trenches shall allow for the proper alignment of ducts into UCVs.

9. Soft spots in the subgrade shall be over-excavated, filled, and compacted.
10. Excavation for trenching shall run true and as straight as practicable. Trenches shall be clear of stones and soft spots.
11. Trench grade shall be sloped to fall 3 inches per 100-feet in general and ¼ inch per foot where possible.
    a. Slope shall fall toward lower UCVs or from high points toward both UCVs.
    b. Slope shall always fall away from building entrances.

B. Fill:
1. Prior to the placement of fill, all groundwater and surface water shall be drained or pumped from the recipient area.
2. Frozen fill shall not be placed.
3. Base:
    a. The subgrade bed to receive fill shall be scarified and moisture conditioned prior to placing materials.
    b. Base material shall be moisture conditioned to within three percent of optimum moisture content and shall be placed in loose, horizontal layers.
    c. The subgrade bed shall be leveled using sand for trenches and gravel for UCVs as necessary to form an even base.
4. Backfill:
    a. Backfill lifts/layers shall not exceed 6 inches before compaction.
5. Compaction: Compaction shall be performed using a vibratory plate or roller or other mechanical device. Compaction through jetting or ponding is not acceptable. Compact per APWA Standard Specification Paragraph 7-10.3 (11).
    a. Bedding: Material shall be compacted to a dense state equaling at least 95 percent of the maximum dry density per ASTM D1557.
    b. Backfill: Material shall be compacted to within 2 feet of the finished surface with a minimum relative compaction of 90 percent of the maximum dry density per ASTM D1557. Material within 2 feet of the finished surface shall be compacted with a minimum relative compaction of 95 percent of the maximum dry density per ASTM D1557.
    c. Waste Disposal: The Contractor shall remove all excavation materials and other construction debris from the site in a timely manner. Materials shall be disposed of legally.

3.3 UNDERGROUND CABLE VAULTS (UCVS)

A. UCVs shall be installed strictly according to the manufacturer's recommendations.

B. Setting and Placement: Excavations shall be free of water and shall have bedding material properly installed prior to setting the UCV. Section seal surfaces must be clean and free from dirt or other material.
1. UCVs shall be set in place by lowering each section of the UCV into the excavation, ensuring that the UCV section is set level, plumb, and firmly positioned, and ensuring that the section gasket/seal is properly installed and watertight prior to setting the next section.
2. The UCVs shall be carefully set in order to ensure that the maintenance hole rim/lid elevation shall be:
    a. Flush: For existing concrete or asphalt in paved and improved areas

b. 2 inches above grade: For landscaped or unimproved areas

C. Knockouts: Knockouts shall be removed by striking the knockout with a single moderately heavy blow with a hammer or similar tool.

D. Duct Entrances: Duct entrances at opposite ends of a UCV shall be at the same level and in the same position with respect to the side walls. The Contractor shall ensure that each duct leaving a UCV in any position shall enter the next UCV in the same relative position.

E. Grouting: Grout shall be applied in a manner to insure filling of all voids in the joints being sealed. Grouting shall be applied to conduit entrances, risers, and covers in addition to any other voids.

F. Racking and Hardware: Install racking and hardware and incidental materials.

G. Grounding/Bonding: Bond all metallic hardware in the vault to the pre-cast bonding tabs. Bond the bonding tabs to the ground rod.

H. Cleaning: The UCV shall be completely cleaned and dried after all construction activity is complete and prior to releasing the UCV to the Owner for the Owner's use.

3.4 LANDSCAPING

A. The Owner will seed and maintain grass areas disturbed by construction activity. Shrubbery damaged, removed or disturbed by construction activity will be replaced by the Owner.

B. Topsoil: Provide loosely compacted topsoil to a depth of 4 inches or depth of excavation for excavations less than 12 inches. Place imported topsoil for all excavations in turfed or landscaped areas. Restore existing grades where disturbed. Topsoil, once properly placed, shall be raked and smoothed. Installation shall be acceptable for landscaping by Owner. Place topsoil per APWA Paragraph 8-01.3(2).

END OF SECTION 270545

SECTION 271000 - COMMUNICATIONS - GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general cabling requirements for the Communications Cabling System.

1.2 RELATED SECTIONS

A. Division 27 Specification Section *Common Work - Sleeves, Penetrations and Firestopping.* Provide sleeves, penetrations, and firestopping as required to support the work of this Section.

B. Division 27 Specification Section *Common Work – Hangers and Supports.* Provide hangers and supports as required to support the work of this Section.

C. Division 28 Specification Section *Security – General Requirements.* Review the specifications to determine if there is any cabling scope of work related to the cabling described in the specification below.

1.3 SUBMITTALS

A. Provide the following per the criteria set forth in Submittals in Division 27 Specification Section *Basic Communications Requirements*:
   1. Product Data
   2. Shop Drawings:
      a. Cable Routing: Provide a cable routing plan if communications cable routing has not been shown on the Drawings, or if the Contractor is proposing a deviation from that shown.
         1) If a routing plan is not required, submit written documentation stating that the routing will be provided as shown on the Drawings, that the Contractor has reviewed the routing shown on the Drawings with the other applicable trades and that all have agreed that it does not create conflicts between the trades, and the routing meets applicable codes, regulations and standards.
         2) If a routing plan is required, submit complete floor plans or detail drawings showing the proposed routing, raceway sizes and locations, and cabling in a manner equal to that of the Drawings. Ensure that any routing changes are coordinated with comparable changes to the raceway routing. Specifically note each location where the proposed routing is different from the Drawings. Where deviations are proposed, submit written documentation detailing the reason for each. Each deviation must be approved in writing by the Engineer prior to proceeding with installation.

b. Termination Block Wall Field Terminations and Elevations: Provide termination block wall field termination diagrams and elevation drawings where such diagrams and elevations have not been shown on the Drawings, or if the Contractor is proposing a deviation from that shown.

1) Where changes to the wall field termination diagrams and elevation drawings are proposed, submit wall field termination diagrams and elevation drawings in a manner equal to that of the Drawings. Specifically note areas where deviations are proposed, and submit written documentation detailing the reason for each. Each deviation must be approved in writing by the Engineer prior to proceeding with installation.

PART 2 - MATERIALS

2.1 GENERAL

A. Manufacturer: Each communication cabling system's components shall be sourced by a single Manufacturer or formally partnered Manufacturers (collectively referred to as the "Manufacturer"). Products shall not be intermixed between different manufacturers unless the Manufacturer of the chosen communications cabling system has listed (in writing) another manufacturer's component as an "approved alternative product" (or equivalent wording) and will warrant the "approved alternative product" as part of the Manufacturer's extended Warranty, or if the product has been specifically called out as a special requirement in the Specifications. Additionally, for a given Manufacturer, all products shall be part of a single product line and the product line shall be specifically engineered "end-to-end" (e.g. the system and all of its components shall have been engineered to function together as a single, continuous transmission path). The communication cabling systems shall be:

1. Belden/CDT
2. CommScope – Systimax
3. Corning (only where specifically listed)
4. Panduit/General Cable "PanGen" Solution

B. Plenum Rating:

1. Cable shall be plenum (CMP, OFNP) rated unless otherwise indicated. Cable shall bear plenum markings.

C. Part Numbers: Refer to the Equipment Schedule(s) on the Communications Construction Drawings for specific manufacturers and part numbers. If no part number is provided, then any part meeting the manufacturer and requirements specified is acceptable.

2.2 PERFORMANCE

A. Protocols/Services:

1. At a minimum, the communications cabling system shall support data network protocols/services at rates up to 10 Gbps for transmission on copper and 10 Gbps for transmission on fiber. It shall support Ethernet, ATM and other network protocols. The communications cabling system shall additionally support RS-232 and other dedicated point-to-point protocols.

2. The communications cabling system shall support PBX telephone services. It shall support analog, digital, and ISDN services, and shall be compatible with direct trunk lines (POTS).

B. Category Rating: Copper components (cable, connectors, etc.) shall meet or exceed the TIA transmission requirements for the Category for which they are rated.
   1. Horizontal Cable shall be rated Category 6A.
   2. Backbone Cable shall be rated Category 3 or higher.

C. Performance Rating: All components (copper and fiber) shall meet or exceed TIA transmission requirements for their component type.

D. Fiber Performance:
   1. Backbone Cable:
      a. Premium low water peak Singlemode (OS2): Provide cable with a maximum attenuation of 0.7 dB/km @ 1310 nm, 0.7 dB/km at 1550 nm and 0.4 dB/km at 1383 (uncabled).

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section *Basic Communications Requirements*. Governing Requirements of particular relevance to this Section include, but are not limited to:
   1. TIA - 568: Commercial Building Telecommunications Cabling Standard
   2. TIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
   3. ANSI 310-D: Cabinets, Racks, Panels and Associated Equipment
   4. TIA 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
   5. ANSI/NECA/BICSI 607: Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings
   6. ANSI J-STD-607: Commercial Building Grounding and Bonding Requirements for Telecommunications
   7. TIA - 758: Customer-owned Outside Plant Telecommunications Cabling Standard
   8. IEEE 802.3 (series): Local Area Network Ethernet Standards
   9. BICSI: Customer Owned Outside Plant Design Manual
   10. BICSI: Information Transport Systems Installation Manual
   11. BICSI: Telecommunications Distribution Methods Manual
   12. BICSI: Telecommunications Cabling Installation Manual
   13. National Electric Code (NFPA 70)

3.2 GENERAL INSTALLATION

A. Maintain separation from other conductors (power, fire alarm, etc.) per NEC requirements and TIA standards.

B. The bending radius and pull strength requirements of all cable as detailed in the Governing Requirements and Manufacturers recommendations shall be strictly observed during handling and installation.

C. Pull cables simultaneously where more than one cable is being installed in the same raceway.

D. Use pulling compound or lubricant where necessary. Use compounds that will not damage conductor or insulation.

E. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cable or raceway.

F. Cable jackets shall not be twisted during installation. Cables showing evidence of twisting shall be replaced at no additional cost to the Owner, regardless of the outcome of cable testing.

G. Cable shall be installed in a continuous (non-spliced) manner unless otherwise indicated on the Drawings. Where splicing may be required in areas not shown on the Drawings due to Cable Spool length limitations or otherwise, the Contractor shall obtain the approval of the Engineer prior to procurement and installation.

H. Provide strain relief to ensure durable connections at all cable termination locations.

I. Pathway/Raceway Validation: The Contractor is responsible for validating pathway/raceway sizing against the amount of cable it is to support for compliance with NEC and TIA 569 cable capacity standards. The Contractor shall notify the Engineer of all raceways the Contractor determines to be insufficient in size and shall await the Engineer's direction prior to procurement and installation.

J. Copper Cables:
   1. Backbone Cable: All pairs shall be terminated. Unless otherwise noted on the Drawings, the installation of un-terminated cable pairs is not acceptable. For shielded cable, bond both ends of the metallic shield (or metallic strength member) to the nearest TGB.
   2. Horizontal Cable: Thoroughly clean and remove foreign material from outlet boxes prior to installation of cable.

K. Coaxial Cable:
   1. Extreme care shall be taken not to kink coaxial cables during installation. Cable ends shall be protected prior to termination.

L. Fiber Cables:
   1. Cables shall be tested on reel prior to installation. Cable which does not pass shall not be installed and shall be replaced at no additional cost to the Owner. "Repairing" cables which do not pass is not acceptable.
   2. All fiber strands shall be terminated. Unless otherwise noted on the Drawings, the installation of unterminated (i.e. "dark fiber") is not acceptable.
   3. Fiber splices shall be fusion. Mechanical splices are not acceptable. Each fusion splice shall be protected in a splice tray or similar protective device that is designed to mount within the enclosure. Bare/stripped optical fiber strands shall be protected with a buffer tube, heat shrink or silicon adhesive to prevent exposure to moisture.

M. Provide Sleeves and Penetrations as necessary where cable must pass through building barriers such as walls, floors or foundations. Firestop all through and membrane penetrations of fire-rated barriers. Sleeves, Penetrations and Firestopping shall be per the requirements of Division 27 Specification Section *Common Work - Sleeves Penetrations and Firestopping.*

3.3 CABLE INSTALLED IN RACEWAY

A. In Conduit or Ducts:
   1. Fill ratios shall not exceed NEC requirements.
   2. Cable shall not be pulled into conduit/ducts until the conduit/duct ends have been prepared for cable installation (i.e. ducts cleaned and swabbed, reamed to eliminate sharp edges, bushings installed (insulated throat for metallic conduits, PVC for PVC conduits), etc.). Cables pulled into conduit/ducts prior to conduit/duct end preparation shall be removed and replaced (after the conduit/duct ends are prepared) at no additional cost to the Owner.
   3. Backbone (riser) cables shall not share conduits/ducts with horizontal cables.
   4. Reinstate pull-wires in conduits and ducts after use to facilitate future addition of cables.

B. In Cable Tray:
   1. Cable shall not be attached to the cable tray (i.e. cable shall be left "loose").
   2. Cable shall be laid in tray in such a way as to present a neat and professional appearance. However, cable shall not be combed (for performance reasons).
   3. For cable tray serving both backbone (riser) and horizontal cabling, install cable in cable tray in such a manner that backbone cabling does not overlap with horizontal cabling – reserve approximately 25 percent of the space in the tray for backbone cabling and the remaining 75 percent for horizontal cabling.
   4. Where cables in cable trays are required to maintain specific distances between each other they shall be firmly secured to maintain this distance at fire rated penetrations.

3.4 CABLE NOT INSTALLED IN RACEWAY (E.G. "EXPOSED"):

A. Cables shall be strapped, fastened or tie-wrapped for support. Staples are not acceptable.
   1. Straps, fasteners, and tie-wraps shall not be over-tightened. Cables showing evidence of over-tightening shall be replaced at no additional cost to the Owner, regardless of the outcome of cable testing.
   2. Straps, fasteners, and tie-wraps shall be plenum or non-plenum rated to match that of associated cable.
   3. Cables shall be loosely grouped by application (horizontal or backbone) and by cable type (Cat 3, Cat 5E, Cat 5, Cat 6, MM Fiber, SM Fiber, etc.). Cable applications and types shall not be intermixed within a grouping.

B. Cables in suspended cable runs shall be supported at varying intervals. Cable spans shall be limited to 5 feet or less, and the length of spans shall vary along the cable path (i.e. a given span should not be exactly the same length as the span preceding or following it – "exact" spans can degrade cable performance).

C. Cable installed on exposed surfaces or structural members shall be installed parallel and perpendicular to the surfaces. Surface contours shall be followed wherever possible. Cables shall be attached to surfaces at intervals not to exceed 3 feet, and the length of spans shall vary along the cable path (i.e. a given span should not be exactly the same length as the span preceding or following it – "exact" spans can degrade cable performance).

D. Attaching cables to pipes, electrical conduit, mechanical items, existing cables, or the ceiling support system (grids, hanger wires, etc. – with the exception of ceiling support anchors) is not acceptable.

E. Cables exiting floor or wall penetrations and running exposed into furniture or casework shall be bundled and wrapped in spiral wrap or split-loom tubing for protection.

F. The quantity of cables installed in j-hooks, straps, and other similar fasteners shall not exceed manufacturer maximum loads for the fastener. Provide additional fasteners as required to meet load and future capacity requirements.

G. Route cable to comply with the Governing Requirements standards and rules for avoiding potential EMI sources of interference and as follows:
   1. Provide clearances of:
      a. 18 inches from light fixtures
      b. 12 inches from electrical power distribution (including conduits and cables)
      c. 4 feet from motors and transformers
   2. Cable pathway shall cross perpendicular to potential EMI sources of interference.

3.5 CABLE IN COMMUNICATIONS ROOMS AND SPACES

A. Cable on backboards:
   1. Lay and dress all cables to allow other cables to enter raceway (conduit or otherwise) without difficulty at a later time by maintaining a working distance from these openings.
   2. Cable shall be routed as close as possible to the ceiling, floor, sides, or corners to insure that adequate wall or backboard space is available for current and future equipment and for cable terminations.
   3. Lay cables via the shortest route directly to the nearest edge of the backboard from mounted equipment or blocks. Secure all similarly routed and similar cables together and attach to D-rings vertically or horizontally, then route over a path that will offer minimum obstruction to future installations of equipment, backboards or other cables.

B. Cable Bundles:
   1. Cables shall be bundled by application (horizontal or backbone) and by cable type (Cat 3, Cat 5E, Cat 5, Cat 6, MM Fiber, SM Fiber, etc.). Cable applications and types shall not be intermixed within a bundle.
   2. Cable bundles shall be combed to present a neat and professional appearance. For performance reasons, combing shall occur from the cable end to a maximum of 20 feet back (or per the Manufacturer's recommendations, whichever is more stringent). For the portion of a cable bundle within the communications room exceeding this requirement (if any), the exterior cables in the cable bundle shall be combed straight. Interior cables shall not be combed (i.e. they shall be left "mixed").

C. Cable in ladder rack on walls: Place larger cable bundles against wall, smaller cable bundles to the inside.

D. Cable straps: Install cable straps to secure cable bundles to cable runway and other supporting equipment. The use of plastic tie wraps for this purpose is not acceptable. Comply with Division 27 Specification Section *Communications - Equipment Room Fittings*.

3.6 CABLE SLACK

A. Cable slack in communications rooms and spaces: Store slack by circling cable around communications room in the Cable Runway as shown on the Drawings.
   1. Provide Slack length as follows:
      a. Inside Plant Cable: 10 feet minimum for all cable types (horizontal and backbone)
      b. Outside Plant Cable:
         1) At termination ends:
            a) Copper Backbone Cable: 10 feet minimum
            b) Coaxial CATV: 10 feet minimum
            c) Fiber Backbone Cable: 50 feet minimum
         2) In UCV's
            a) See OUTSIDE PLANT CABLE INSTALLATION below
   2. Where Cable Runway does not exist or where slack storage is not called out on the Drawings, slack shall be stored as follows:
      a. Copper Cable:
         1) Horizontal: Slack shall be stored in a serpentine loop manner, not in the form of a circular "loop" (for performance reasons).
         2) Backbone: Slack shall be stored in circular "loops".
      b. Coaxial CATV: Slack shall be stored in circular "loops".
      c. Fiber Cable: Slack shall be stored in circular "loops".

B. Cable slack at the work area outlet: Provide 1 foot of slack. Slack shall be stored in a serpentine loop manner, not in the form of a circular "loop" (for performance reasons).

C. In cases of extreme congestion, notify the Engineer and await the Engineer's direction prior to installation.

3.7 OUTSIDE PLANT INSTALLATION

A. Duct/Direct-Buried:
   1. Mandrels: Prior to installation of cable, each duct shall be cleaned of debris with a wire brush or swab and shall be proven out with a test mandrel of sufficient length to verify the TIA minimum bend radii requirements and with a diameter which is ¼ inch smaller than the inside diameter of the duct. Duct shall be cleaned a minimum of two times in the same direction and swabbed with clean rags until the rag comes out of the conduit clean and dry. Swab away from buildings for duct sections connected to buildings.

2. Cables shall be installed in strict compliance with the Governing Requirements and manufacturers recommendations. Bending radius, pulling tension, other mechanical stresses, and pulling speed as detailed in the manufactures recommendations and TIA standards shall be strictly observed. Pulling tension shall be monitored for all runs of 300 feet or longer. Acceptable monitoring devices are:
   a. Winch with a calibrated maximum tension
   b. Breakaway link (swivel)
   c. In-line tensiometer
3. Cable reels shall be set up on the same sides of UCV's as conduit sections in which cables are to be placed. Reels should be leveled and aligned with conduit sections to prevent twisting of cables during installation into conduits. Cables shall be pulled into conduits from tops of reels in long smooth bends. Cables shall not be pulled into conduits from bottoms of reels. A cable feeder guide (shoe) of suitable dimensions shall be used between the cable reel and the face of the duct to protect the cable and guide it into the duct. As the cables are payed off the reel, they shall be carefully inspected for sheath defects. If defects are found during the pulling operation or if the cable on the reel binds, twists, or does not pay off freely, the pulling operation shall be stopped immediately and the Owner's representative notified.
4. Cables of 1-¼ inches or larger diameter shall be equipped with factory installed pulling eyes. Pulling grips are to be used for cables smaller than 1-¼ inches in diameter. Grips with rings to prevent the grips from slipping shall not be beaten into the cable sheath. A ball-bearing based swivel shall be used between the pulling-eyes or grips and the pulling strand.
5. Once pulling begins, and tension is applied to the cable, the pull shall be continued at a steady rate. If it is necessary to stop the pull at any point, the pull should be stopped but the tension should not be released unless it is necessary to do so.
6. Cables shall not be placed in ducts other than those specifically indicated on the Drawings. For new ductbank, cables shall be installed in the lowest available conduit in a duct bank, working up as additional cables are installed or as detailed on the Drawings.
7. Where cables are pulled through UCV's, duct selections shall be the same at both ends of UCV's unless specifically noted on the Drawings. Changes in duct selections, especially in elevations, shall be avoided to ensure that no damage occurs to the cable sheaths and that pulling tensions are kept as low as possible.
8. A sufficient length of cable shall be left in each UCV to properly rack the cable, and to provide for splicing operations which may be required outside of the UCV. In the event that the UCV contains cabling routed directly to a building entrance, a sufficient length of cable entering the building shall be left in the UCV to allow for re-termination in the building without the use of a splice in the event of future cable damage between the UCV and the building. Cables in UCV's shall be racked as soon as practicable and in no case shall racking occur greater than one week after cable installation. Cables in UCV's shall be routed to avoid blocking duct access.
9. Cables shall be fed into ducts from the end of the duct that creates the least sidewall pressure on a bend during installation (i.e. cable should be fed from the end closest to the bend).

10. Use pulling compound or lubricant where necessary. Lubricants shall be specifically produced for the installation of telecommunications cable, shall be compatible with the cable jacket material and shall be used in accordance with manufacturer's recommendations. Soap-based lubricants shall not be used. Where cable is pulled through a UCV, the cable shall be re-lubricated prior to feeding into the next duct. Immediately after cables have been installed, exposed cables in UCV's and at termination points shall be cleaned of lubricants using dry rags.
11. Cable ends shall be sealed and protected with end caps immediately after installation and until terminated in a termination enclosure, in order to prevent moisture entry into the core of filled cables and to prevent damage during installation.
12. Installation of outdoor rated cable at building entrances shall comply with the *National Electric Code (NEC)* Article 800 "50-ft rule" (i.e. total exposed outdoor rated cable length within a building shall not exceed 50 feet). Where this is not possible due to existing field conditions, the Contractor shall notify the Engineer and await direction prior to cable installation.
13. Building Entrances: All in-use and spare conduits entering the building from the outside plant shall be sealed to prevent intrusion of water, gases, and rodents.

END OF SECTION 271000

SECTION 271100 - COMMUNICATIONS - EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing equipment and materials for TIA compliant communications equipment rooms and spaces including, but not limited to, telecommunications rooms, equipment rooms, entrance facilities, etc. General requirements for equipment room fittings are covered in Division 27 Specification Section *Communications – General Requirements*.

1.2 RELATED SECTIONS

A. The requirements of Division 27 Specification Section *Electrical Technology - General Requirements* shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

B. The requirements of Division 27 Specification Section *Electrical Technology - Grounding and Bonding* shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS

A. Provide the following per the criteria set forth in Submittals in Division 27 Specification Section *Basic Communications Requirements*:
   1. Product Data
   2. Shop Drawings:
      a. Provide the following for each Communication Room, if: a) Communications Rooms are not shown on the Drawings; b) Communication Rooms are only shown as “Typical” on the Drawings; c) or the Contractor is proposing a deviation to the Drawings:
         1) Wall elevations (all four walls)
         2) Plan view/layout
      b. Provide the following only if elevations have not been shown on the Drawings, or if the Contractor is proposing a deviation.
         1) Wall Field Cable/Jumper Management Elevations, including designation of cable and pair terminations within the wall field.

PART 2 - MATERIALS

2.1 GENERAL

A. Manufacturer: Racks, frames, cabinets, enclosures, rack cable distribution hardware, cable runway (ladder rack), and other distribution and incidental components shall be manufactured by a single Manufacturer unless specifically stated otherwise. The manufacturer shall be:
   1. Chatsworth Products, Inc. (CPI)

B. Part Numbers: Refer to the Equipment Schedule(s) on the Communications Construction Drawings for specific manufacturers and part numbers. If no part number is provided, then any part meeting the manufacturer and requirements specified is acceptable.

C. Color: Unless otherwise indicated, the color of all cable runway, equipment racks, frame, and cabinets, distribution hardware, and other distribution and incidental equipment shall be:
   1. Black

D. Seismic Bracing: Equipment shall be seismically braced as required by code. Bracing shall be rigid – non-rigid bracing (chains, cables, etc.) is not acceptable, unless otherwise specified by code. Seismic bracing hardware shall be provided by the manufacturer, or shall be approved or recommended by the manufacturer. Where no manufacturer hardware, approval, or recommendation is available, the seismic assembly shall be approved by a licensed structural engineer.

2.2 CABLE RUNWAY (LADDER RACK)

A. Cable runway system shall be complete with all fittings, miscellaneous hardware, and other incidental hardware required for a complete and fully fitted system, including but not limited to splice kits, support hangers, rods, and brackets, center supports, j-bolts, foot kits, vertical wall brackets, wall angles, support hardware, grounding hardware, and protective end caps for exposed cable runway ends. Provide as shown on the Drawings or as defined below:
   1. Straight Section (Standard Rung Spacing): Cable runway shall be available in 6 inch, 12 inch, 18 inch, 24 inch widths and shall have runway cross-members (rungs) spaced at 12 inch intervals.
   2. Straight Section (Alternate Rung Spacing): Alternate Rung Spacing Cable runway shall be available in 6 inch, 12 inch, 18 inch, 24 inch widths and shall have runway cross-members (rungs) spaced at alternating 12.5 inch and 13.81 inch intervals. Alternate rung spacing runway is used to simplify vertical alignment of cable runway installed across the top of equipment racks with standard 6 inch vertical cable management sections.
   3. Triangular Support Brackets: Triangular Support Brackets shall be provided for all locations where cable runway is to be mounted on a wall. Triangular Support Brackets shall be sized and provided in quantities according to the width and fully loaded capacity of the cable runway to be supported.
   4. Radius Drop: Radius Drops shall be provided for all locations where cable is to drop from one section of cable runway to another lower section of cable runway, or is to drop from cable runway to equipment racks, frames, or cabinets. Radius Drops shall be either Cross Member or Stringer type according to their application, and sized in widths according required to support their application.

5. Elevation Kits: Elevation kits shall be provided for all equipment racks and frames where cable runway is routed across the tops of equipment racks and frames and is not mounted at the same height as the tops of the equipment racks or frames. Elevation Kit height shall be sized per the distance between the top of the rack or frame and the cable runway.
6. Rack-to-Runway Mounting Plate: Mounting Plates shall be provided for all equipment racks and frames where cable runway is mounted directly to the top of equipment racks or frame. Mounting Plate shall be 3 inches wide and sized according to the width of the cable runway to be attached.
7. Vertical Wall Bracket: Vertical Wall Brackets shall be provided for all locations where cable runway is vertically mounted on the wall(s).
8. Wall Angle Support: Wall Angle Supports shall be provided for all locations where cable runway stops at walls or where Triangular Support Brackets cannot be utilized due to field conditions. Wall angles shall be sized and provided in quantities according to the fully loaded capacity of the cable runway to be supported.

2.3 EQUIPMENT RACKS, EQUIPMENT FRAMES, SERVER FRAMES AND CABINETS

A. Equipment shall be free standing and shall be complete and fully fitted with all miscellaneous and incidental hardware required, including but not limited to hardware required for assembly, securing to floor, grounding, and seismic bracing (as required by local codes). Height shall be as shown on the Drawings. Provide as shown on the Drawings and as follows:
   1. Equipment Racks: Equipment racks shall be 19 inch wide with universal alternating hole patterns on both sides of the posts, 3 inch channels, 2 posts, top angles, self-supporting bases, and assembly hardware.
   2. Equipment Frames: Equipment frames shall be 19 inch wide with universal alternating hole patterns on both sides of the posts, 3 inch channels, 4 posts, top angles, self-supporting bases, top and bottom extension pans, and assembly hardware.
   3. Server Frames: Server frames shall be 19 inch wide with 5/8 inch-5/8 inch-1/2 inch alternating square hole pattern complete with cage nuts for mounting equipment, 3 inch by 1.265 inch C-channels, 4 posts, top angles, self-supporting bases, and top and bottom extension pans, plate nuts and assembly hardware.

2.4 RACK-MOUNT ACCESSORIES

A. Provide as shown on the Drawings and as follows:
   1. Horizontal Power Strip: Horizontal power strips shall be complete with mounting hardware for direct to rack installation. Outlet type, outlet count, receptacle type and amperage rating shall be as stated on drawings and/or equipment schedule. A power cord with sufficient length (a minimum of 5 feet) shall be equipped.
   2. Vertical Power Strip: Vertical power strips shall be complete with mounting hardware to mount off from back of vertical cable management sections. Where vertical cable management sections are not used, provide standoff brackets to mount to back of equipment rack/frame posts. Outlet type, outlet count, receptacle type and amperage rating shall be as stated on drawings and/or equipment schedule. A power cord with sufficient length (a minimum of 5 feet) shall be equipped
   3. Single-sided Shelf: Shelf shall be single sided, with side mount brackets 5.25 inches (3U) high, and shall be capable of mounting flush with the face of the rack.

2.5 CABLE MANAGEMENT

A. Provide as shown on the Drawings and as follows:
   1. Horizontal Cable Management Panels: Horizontal cable management panels shall be 19 inches wide, complete with section covers, and shall be provided in heights (rack units) as shown on the Drawings.
   2. Vertical Cable Management Sections: Vertical cable management sections shall be complete with double-hinged section covers, "finger" style side cable openings capable of accommodating up 48 patch cords or horizontal cables, shall be single or double sided as shown on the Drawings, and shall be provided in widths and heights as shown on the Drawings.
   3. Upper Transition Tray: Provide as shown on Drawings. Unless shown otherwise on Drawings, upper transition trays shall be mounted at the top of equipment racks, frames and enclosures to route patch cables and jumpers. Upper transition trays shall be 19 inches wide.
   4. Distribution Rings: Provide for all locations where cable or jumpers will be routed on backboards and similar surfaces. Size shall be appropriate to the quantity of cable to be supported, and shall be a minimum of 2 inches in diameter. Rings shall be manufactured by CPI, or equal. Type of ring shall be as follows:
      a. C-Rings ("open" rings): Provide for those cables or jumpers which will likely be subjected to frequent moves, adds, or changes.
      b. D-Rings ("closed" rings): Provide for those cables or jumpers not likely to be subjected to frequent moves, adds, or changes.

2.6 BACKBOARDS

A. Provide backboards as shown on the Drawings. Backboards shall be ¾ inch exterior grade Douglas Fir A-C plywood, void free, 2440-mm (8 feet) high unless otherwise noted, capable of supporting attached equipment. Width shall be as required to fully cover walls. Backboards shall be as follows:
   1. Backboards shall be fire-rated or treated on all sides with a minimum of two coats of fire retardant, non-conductive, light colored semi gloss paint (to match the color of the room).

2.7 GROUNDING AND BONDING

A. Bonding Conductor for Telecommunications (BCT): Provide #6 AWG insulated solid copper conductor (green) to bond all non-current-carrying metal telecommunications equipment and materials to the nearest TGB.

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section *Basic Communications Requirements*. Governing Requirements of particular relevance to this Section include, but are not limited to:

1. TIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
2. ANSI 310-D: Cabinets, Racks, Panels and Associated Equipment
3. TIA 606-A: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
4. ANSI/NECA/BICSI 607: Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings
5. ANSI J-STD-607: Commercial Building Grounding and Bonding Requirements for Telecommunications
6. TIA 607: Commercial Building Grounding and Bonding Requirements for Telecommunications

B. Seismic Bracing: Install seismic bracing as required by code.

3.2 CABLE RUNWAY (LADDER RACK)

A. Cable Runway shall be installed per manufacturer's instructions and shall be installed with flat (rung) side up/out. Install with ends cut square, and reamed to remove burrs and sharp edges. Cap cut ends with manufacturer's recommended caps. Affix cable radius drop outs wherever cable will "waterfall" from one runway elevation to another, or from runway to equipment.

3.3 EQUIPMENT RACKS, EQUIPMENT FRAMES, SERVER FRAMES AND CABINETS

A. Install equipment complete with all required incidental hardware and materials.

B. Bond all non-current carrying metal telecommunications equipment and materials to the nearest TGB. Ensure that grounding is provided across all cable runway splices and between cable runway and all equipment racks/frames, etc.

C. Free Standing Equipment Racks and Frames:
1. Secure cable runway to equipment racks/frames and to walls as shown on the Drawings. Secure racks/frames to floor per manufacturer's instructions.
   a. Rack-to-Runway Mounting Plate: Secure to cable runway and equipment racks and frames. Mounting plates shall be mounted either parallel or perpendicular, depending upon the orientation of the ladder rack
2. When installing Vertical Cable Management Sections between equipment racks/frames, install management such that the management trough is as far back as possible between the racks/frames, to ensure a clean/even front side of the rack/frame.
3. When installing multiple adjacent equipment racks/frames, bolt adjacent racks (and management, where shown) together per manufacturer's instructions to ensure a stable, rigid frame.

3.4 CABLE MANAGEMENT

A. Distribution rings: Mount at minimum 1 foot intervals.

3.5 BACKBOARDS

A. Mount backboards on walls in locations shown on the Drawings with base of backboard at +12 inches AFF (unless otherwise noted on the Drawings), with the "A" side exposed. Securely fasten plywood to wall-framing members to ensure that it can support attached equipment.
   1. In the instance of the backboard being painted, the Fire-Rated Stamp on the Plywood Backboard shall remain visible and shall not be painted over.

3.6 GROUNDING AND BONDING

A. Bonding Conductor for Telecommunications (BCT): Bond all non-current carrying metal telecommunications equipment and materials to the nearest TGB with a bonding conductor.
   1. Route along the shortest and straightest path possible with minimal bends.
   2. Bends shall be sweeping.
   3. Bonding conductors shall be continuous (without splices) and shall be insulated from their support.
   4. Ensure that bonding breaks through paint to bare metallic surface of all painted metallic hardware.

END OF SECTION 271100

SECTION 271119 - COMMUNICATIONS - TERMINATION EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements for equipment to terminate communications cable in communications equipment rooms and spaces. General requirements for termination equipment are covered in Division 27 Specification Section *Communications - General Requirements.*

1.2 RELATED SECTIONS

A. The requirements of Division 27 Specification Section *Communications - General Requirements* shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS

A. Comply with the Submittal portion of Division 27 Specification Section *Basic Communications Requirements*. Provide submittal information for the following:
   1. Product Data

PART 2 - MATERIALS

2.1 GENERAL

A. Manufacturer: Unless otherwise indicated, equipment in this Section shall be of the same Manufacturer as that specified under Division 27 Specification Section *Communications - General Requirements*.

B. Part Numbers: Refer to the Equipment Schedule(s) on the Communications Construction Drawings for specific manufacturers and part numbers. If no part number is provided, then any part meeting the manufacturer and requirements specified is acceptable.

2.2 PATCH PANELS

A. Provide patch panels in sizes and quantities as required to support all cables to be terminated. The sizes and quantities shown on the Drawings are for representative purposes only, and may or may not be the final sizes and quantities required. The Contractor shall provide sizes and quantities as required to support all cables to be terminated.

1. Copper: Copper patch panels shall be rack mountable and sized as shown on the Drawings. Patch panel connectors shall be 8-position/8-conductor, insulation displacement (IDC), non-keyed, and shall accept modular 8-position/8-conductor plugs. Patch panels shall support a universal (T568A and T568B) wiring pattern, shall meet or exceed the transmission requirements for connecting hardware as specified in the Division 27 Specification Section *Communications - General Requirements* for the Category for which they are rated, shall be equipped with pre-manufactured cable management support bar/strain relief for supporting cables behind the patch panel, and shall be complete with all incidental materials necessary for mounting and installation of the panel and support of the cables which shall be connected to it. Patch panels shall be available in 24-port and 48-port styles.
    a. Horizontal Copper Patch Panels: Provide for terminating copper horizontal cables. Patch panel Category rating shall be the same as that specified under Division 27 Specification Section *Communications - General Requirements*.
2. Fiber: Fiber patch panels shall be dual purpose, capable of both termination/connectorization and splicing (fusion or mechanical) of fiber in the same enclosure, shall support both regular and high-density connectors, and shall be sized as shown on the Drawings. Fiber patch panels shall consist of enclosures pre-assembled with connector panels, blank connector panels (for unused connector slots), strain relief, splice trays (as required) and splice incidentals. Fiber patch panels shall be complete with bulkheads as required to accommodate all fiber strands within the panel, and filler plates as required for all unused bulkhead slots (see Division 27 Specification Section *Communications - Faceplates and Connectors)*, and with all incidental materials necessary for mounting.
    a. Rack Mount: Rack Mount Patch Panels shall be 19 inches wide and shall be available in 24/48 (1U), 48/96 (2U), and 72/144 (4U) port sizes.

2.3 OTHER TERMINATION EQUIPMENT

A. Building Entrance Protectors: Provide Building Entrance Protectors (BEP's) for the protection all copper cables that originate or terminate externally. Each BEP shall be provided complete with plug-in protector modules. Protector modules shall provide over-voltage and sneak current protection. For tail-in/tail-out style protectors, provide tail-in and tail-out lengths as required by the application. Provide in sizes and quantities as shown on the Drawings.

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section *Basic Communications Requirements*. Governing Requirements of particular relevance to this Section include, but are not limited to:
    1. TIA - 568: Commercial Building Telecommunications Cabling Standard
    2. TIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
    3. ANSI 310-D: Cabinets, Racks, Panels and Associated Equipment
    4. TIA 606-A: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

5. ANSI/NECA/BICSI 607: Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings
6. ANSI J-STD-607: Commercial Building Grounding and Bonding Requirements for Telecommunications
7. TIA - 758: Customer-owned Outside Plant Telecommunications Cabling Standard

3.2 PATCH PANELS

A. Copper:
   1. Horizontal Patch Panels: Cables shall be terminated sequentially and alphabetically by room number and sequential outlet number (within a room) left to right, from patch panel to patch panel (e.g. ports which terminate outlet cables from room 215A shall be terminated prior to ports which terminate outlet cables from room 220). Use the T568B wiring pattern.

B. Fiber:
   1. Fiber Patch Panels: Strands shall be connected sequentially left to right and from top to bottom. Terminate singlemode fibers in first available ports and multimode in last available ports.

3.3 OTHER TERMINATION EQUIPMENT

A. Building Entrance Protectors (BEP's): Install BEP's for both ends of outside plant copper cables per manufacturer's instructions. All outside plant copper cables shall be routed through BEP's. Connect each BEP's protector ground lug to the nearest TGB with #6 AWG copper grounding conductor.
   1) Install as shown on the Drawings. Install all required hardware and kits for field fusion splicing in splice closure and for sealing and mounting the closures.
   2) Grounding/Bonding: If non-dielectric cable, connect to the nearest TGB with #6 AWG copper grounding conductor.

b. Outdoors:
   1) Install where shown on the Drawings and where required due to Cable Spool length limitations. If, in the Contractor's opinion, additional enclosures will be required, the Contractor shall obtain the approval of the Engineer prior to installation.
   2) Direct-bury or enclosures located in ducts are not permitted unless approved by the Engineer prior to installation.
   3) Racking: Splice enclosures located in underground cable vaults/manholes shall be supported on racks (at both ends) and shall be routed to avoid blocking duct access.

END OF SECTION 271119

SECTION 271300 - COMMUNICATIONS - BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements for backbone cable within the Communications Cabling System. General requirements for backbone cable are covered in Division 27 Specification Section *Communications - General Requirements.*

1.2 RELATED SECTIONS

A. The requirements of Division 27 Specification Section *Communications - General Requirements* shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS

A. Comply with the Submittal portion of Division 27 Specification Section *Basic Communications Requirements*. Provide submittal information for the following:
   1. Product Data

PART 2 - MATERIALS

2.1 GENERAL

A. Manufacturer: Unless otherwise indicated, equipment and materials in this Section shall be of the same Manufacturer as that specified under Division 27 Specification Section *Communications - General Requirements*.

B. Part Numbers: Refer to the Equipment Schedule(s) on the Communications Construction Drawings for specific manufacturers and part numbers. If no part number is provided, then any part meeting the manufacturer and requirements specified is acceptable.

2.2 COAXIAL CATV

A. General: Coaxial cable shall be 75 ohm cable, solid conductor. Cable shall be sized as shown on the Drawings.

B. Inside Plant (Interior): Provide indoor rated cable.
   1. Trunk:
      a. Series 11: Cable shall be Series 11, low loss, quad shield.
   2. Interconnect: Provide for interconnecting Head-End and Trunk cables. Cable shall be Series 6, 18 AWG, low loss, quad shield.

2.3 FIBER

A. General: Provide fiber optic cable in quantities, strand counts, and types (singlemode, multimode, or hybrid) as shown on the Drawings. Fiber cable shall be all-dielectric, shall conform to Bellcore and RUS standards, and shall be as further specified under Division 27 Specification Section *Communications - General Requirements*.

B. Outside Plant (Exterior): Provide indoor/outdoor rated cable. Cable shall be loose buffered (loose tube) with a central strength member, and shall be dry cable design with dry water blocking technology that eliminates the need for or use of flooding compound.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide cross connect wire to Owner.

END OF SECTION 271300

SECTION 271500 - COMMUNICATIONS - HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes specific requirements for horizontal cable within the Communications Cabling System. General requirements for horizontal cable are covered in Division 27 Specification Section *Communications - General Requirements.*

1.2 RELATED SECTIONS

A. The requirements of Division 27 Specification Section *Communications - General Requirements* shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS

A. Comply with the Submittal portion of Division 27 Specification Section *Basic Communications Requirements*. Provide submittal information for the following:
   1. Product Data

PART 2 - MATERIALS

2.1 GENERAL

A. Manufacturer: Unless otherwise indicated, equipment and materials in this Section shall be of the same manufacturer as that specified under Division 27 Specification Section *Communications - General Requirements*.

B. Part Numbers: Refer to the Equipment Schedule(s) on the Communications Construction Drawings for specific manufacturers and part numbers. If no part number is provided, then any part meeting the manufacturer and requirements specified is acceptable.

2.2 COPPER

A. Horizontal Cable: Cable shall be 4 pair UTP, solid copper conductors insulated with color coded PVC. Copper cable Category rating shall be the same as that specified under Division 27 Specification Section *Communications - General Requirements.*
   1. Color shall be:
      a. Data/VOIP/Voice : Yellow
      b. WAP: Green
      c. Security: Black

2.3 COAXIAL CATV

A. Coaxial horizontal cable shall be 75 ohm Series 6, 18 AWG solid conductor, low loss, quad shield with 90% braid.

PART 3 - EXECUTION

3.1 THIS SECTION NOT USED

END OF SECTION 271500

SECTION 271543 - COMMUNICATIONS - FACEPLATES AND CONNECTORS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements for faceplates and connectors within the Communications Cabling System. General requirements for faceplates and connectors are covered in Division 27 Specification Section *Communications - General Requirements.*

1.2 RELATED SECTIONS

A. The requirements of Division 27 Specification Section *Communications - General Requirements* shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS

A. Comply with the Submittal portion of Division 27 Specification Section *Basic Communications Requirements*. Provide submittal information for the following:
   1. Product Data

PART 2 - MATERIALS

2.1 GENERAL

A. Manufacturer: Unless otherwise indicated, equipment in this Section shall be of the same Manufacturer as that specified under Division 27 Specification Section *Communications - General Requirements*.

B. Part Numbers: Refer to the Equipment Schedule(s) on the Communications Construction Drawings for specific manufacturers and part numbers. If no part number is provided, then any part meeting the manufacturer and requirements specified is acceptable.

2.2 FACEPLATES

A. General: Provide faceplates for outlets in the locations and gang counts as shown on the Drawings or as specified below. Faceplates shall be complete with blank inserts/fillers for covering unused connector openings. Faceplates and fittings shall be dimensionally suitable for securely mounting connectors, providing a snug and sure fit – loose connectors are not acceptable. Faceplates shall be complete with port identification labels, and shall be provided with appropriate adapters, fittings and adapters as required.

B. Color: The color of non-stainless steel faceplates shall be "Off-White" unless specified below.

C. Faceplates/Fittings:
   1. For wall-mount telephone locations:
      a. Faceplates shall be brushed stainless steel with stainless steel mounting lugs suitable for mounting wall-mount telephones. Faceplates shall be dimensionally suitable for securely mounting 8-position/8-conductor IDC (RJ45 style) connectors.
   2. For specialized mounting requirements (including but not limited to furniture, furniture "pop-ups" and enclosures, floor-boxes, poke-throughs, surface mounted raceway, etc.):
      a. Provide faceplates and fittings as required to support the specialized mounting. Faceplates and fittings shall be manufactured specifically for the equipment that they are to be mounted into ("general purpose" faceplates field modified for the specialized use are not acceptable unless specifically noted otherwise on the Drawings). Faceplates and fittings shall be approved by both the equipment manufacturer and the communications cabling system manufacturer and shall be coordinated and verified compatible by the Contractor, equipment manufacturer and cabling system manufacturer prior to procurement and delivery. The provision of the correct faceplates and fittings for use in specialized mounting requirements is the sole responsibility of the Contractor.
   3. For walls and other non-specialized locations:
      a. Faceplates used for telecommunications outlets shall be made of the same material as electrical outlet faceplates. Faceplates shall be capable of flush mounting connectors.
      b. Standard single gang faceplates shall have two jack openings.
   4. For Wireless Access Point (WAP) and Security Camera (SC) locations:
      a. Provide surface housing outlet box. Surface housing shall be dimensionally suitable for securely mounting 8-position/8-conductor IDC (RJ45 style) connectors.

D. Provide blank faceplates, matching those faceplates in use, for all unused Communications Systems Outlets including, but not limited to wall mounted Back Boxes and empty gangs in Floor Boxes and Poke-Thru's.

2.3 CONNECTORS

A. General: Connectors shall meet or exceed the TIA standards and as called for in the Governing Requirements.

B. Horizontal:
   1. Copper: Copper connectors shall be 8-position/8-conductor, insulation displacement connector (IDC), non-keyed, and shall accept modular 8-position/8-conductor plugs. Connectors shall have a universally color-coded wiring pattern for T568B. Copper connectors Category rating shall be the same as that specified under Division 27 Specification Section *Communications - General Requirements*.
      a. Color shall be:
         1) Data: Yellow
         2) WAP: Green
         3) IP Based Security: Black

2. Coaxial CATV:
   a. Connectors shall be F-type.

PART 3 - EXECUTION

3.1 FACEPLATES

A. Install all faceplates level and perpendicular to the floor. If long side of existing outlet box is mounted horizontal, then rotate faceplate counter-clockwise.

3.2 CONNECTORS

A. Horizontal:
   1. Copper: Terminate connectors using the T568B wiring pattern at both ends of the cable.

END OF SECTION 271543

SECTION 271710 - COMMUNICATIONS - IDENTIFICATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements for identification/administration of the Communications Cabling System.

1.2 SUBMITTALS

A. Comply with the Submittal portions of Division 27 Specification Sections *Basic Communications Requirements* and *Communications - General Requirements*. Provide submittal information for the following:

Identification and Administration (see Part 2 – Materials: Identification and Administration herein):

a. Provide a list of proposed hand-carried or computer software-based identification/label makers, and a list of proposed materials for identifiers/labels.

b. Provide actual samples of labels to be created for each system component to be labeled.

PART 2 - MATERIALS

2.1 IDENTIFICATION AND ADMINISTRATION

A. Identifiers (labels) shall be as recommended in TIA 606-A, unless noted otherwise herein.

B. Labels shall be permanent (i.e. not subject to fading or erasure) and permanently affixed. Handwritten labels are not acceptable.

C. For identification of materials and equipment interior to the facility:

For cables: Labels shall be created by a hand-carried label maker or an equivalent computer/software-based label making system.

a. For horizontal cables: Labels shall include a clear vinyl adhesive wrapping applied over the label in order to permanently affix the label to the cable. Using transparent tape to affix labels to cables is not acceptable.

b. For backbone cables: Labels shall be affixed or engraved on hard plastic markers.

For equipment (racks, frames, cabinets, enclosures, etc.): Provide engraved nameplates.

D. For identification of materials and equipment in the outside plant:

Labels shall be waterproof (even when submerged) and engraved on hard plastic markers. Lettering shall be black, markers shall be white.

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section *Basic Communications Requirements*. Governing Requirements of particular relevance to this Section include, but are not limited to:
   1. Identification and Administration:
      a. TIA 606-A: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

3.2 IDENTIFICATION AND ADMINISTRATION

A. General
   1. The Contractor is solely responsible for the completeness, accuracy, and placement of identifiers (labels). Incorrectly identified components are the sole responsibility of the Contractor.
      a. Where questions arise regarding the correct identifier for a given component, the Contractor shall notify the Owner and Engineer and await direction prior to proceeding.
   2. The Contractor shall install identifiers where indicated and at locations for best viewing convenience without interfering with the operation and maintenance of equipment.
   3. The Contractor shall coordinate names, abbreviations, colors, and other designations with the corresponding designations indicated in the Construction Documents and as required by codes and standards.
   4. The Contractor shall use consistent identifiers throughout the Project.
   5. The Contractor shall clean surfaces of dust, loose material, and oily films before applying self-adhesive identifiers.
   6. Two weeks prior to a particular component or group of components being labeled, the Contractor shall review the proposed identification scheme, label(s), and procedure for affixing label(s) with the Owner and Engineer. Contractor shall not proceed with labeling until the Owner and Engineer have approved the proposed identification scheme, label(s), and procedure for affixing label(s).
   7. The Contractor shall physically verify that the component to be identified matches the label to be affixed, prior to affixing the label.

B. Communications Cable Color Coding: Industry standard color coding shall be applied to all cable termination fields. The same color shall always be applied to both ends of any given cable. Cross-connections are generally made between termination fields of different colors. The color may be applied to the backboard behind the termination equipment, may be the color of a cover on the termination equipment, or may be the actual color of the insert label on the termination equipment. The following color code shall be used:
   1. Orange: Identification of the telecommunication service (telephone company) demarcation point.
   2. Green: Identification of network connections on the customer side of the demarcation point.
   3. White: Identification of first-level backbone in the building containing the main cross-connect or may be used to identify the second-level backbone in buildings not containing the main cross-connect.

4. Gray: Identification of the second-level backbone in the building containing the main cross-connect.
5. Blue: Identification of the horizontal cables. A blue color coding is only required at the closet end of the cable, not at the outlet end of the cable.
6. Brown: Identification of inter-building backbone cables.
7. Yellow: Identification of auxiliary circuits, alarms, maintenance, security, and other miscellaneous circuits.
8. Red: Identification of key telephone systems.

C. Cable Types shall be used for identification and labeling purposes, and shall be as follows:
1. S: Horizontal cable - copper (Category 3, 5E, 6, 6E, coax, etc. – inside plant only)
2. SF: Horizontal cable - fiber (typically multimode – inside plant only)
3. SM: Singlemode fiber backbone (inside and outside plant)
4. MM: Multimode fiber backbone (inside and outside plant)
5. H: Hybrid/composite singlemode and multimode fiber backbone (inside and outside plant)
6. C: Copper backbone used for voice grade communications (inside and outside plant)
7. D: Copper backbone used for data grade communications (inside and outside plant)
8. CX: Coax backbone (inside and outside plant)

D. Component Identification (Labels):
1. Telecommunications Rooms: Telecommunications Rooms shall be labeled as shown on the Drawings. In general, Telecommunications Rooms are labeled by floor and direction. For example, the north Telecommunications Room on the first floor shall have the label "1N."
2. Equipment Racks, Frames, Cabinets, Enclosures, etc.: Equipment shall be labeled sequentially within a given closet and as shown on the Drawings. Labels shall be of the form "EX" where "E" stands for "(R)ack", "(F)rame", "(C)abinet", or "(E)nclosure" and "X" is the sequential equipment number within a given closet. For example: The first rack in a given Telecommunications Room would have the label "R1", the second "R2" and so on.
3. Inside Plant Cables and Equipment:
   a. Outlets:
      1) Faceplate: Faceplates shall identify the room in which the outlet resides, Telecommunications Room at which the outlet terminates, and the sequential number of the outlet with the room, separated by a dash ("-"). For example, the fourth faceplate within room 110 which terminates in Telecommunications Room "1N" shall have the label "110-1N-4".
         a) The faceplate sequential number within the room shall be calculated by first numbering the faceplates along the outside walls in a clockwise direction from the doorway, and then proceeding to outlets in the middle of the room.
   b. Cables:
      1) Label Location: Labels shall be affixed at each end of the cable.
      2) Horizontal Cables: Horizontal cables shall be labeled with the same label as the patch panel port to which the horizontal cable is connected in the Telecommunications Room.
   c. Patch Panels:
      1) General: Patch panels shall be labeled sequentially within a Telecommunications Room, by Cable Type, top to bottom, left to right. For example, the 4th horizontal copper patch panel shall have the label "S4."

2) Horizontal Copper Patch Panels:
   a) Ports shall be labeled with the room number, sequential outlet (faceplate) number, and the sequential horizontal port number, each separated by a period (“.”). For example, the patch panel port which terminates the fourth outlet and third port within room 215 shall have the label “215.4.3”.
3) Components Specific to Fiber Patch Panels:
   a) Connector Panels/Adapter Plates: Connector panels are typically pre-labeled by the manufacturer with labels such as “A”, “B”, etc. or “1”, “2”, etc. For connector panels which are not pre-labeled, connector panel labels shall be of the form “X” where “X” is an alphabetical letter identifying the sequential connector panel within the patch panel.

4. Outside Plant Cables and Equipment:
   a. Copper Building Entrance Protectors:
      1) Outside Horizontal Distribution:
         a) Station Entrance Protectors: Label with the horizontal outlet identifier (see Outlets above).

E. Outlet References and Labels Spreadsheet
1. An Outlet Reference Spreadsheet (a sample of which is attached to the end of this Specification Section) shall be maintained by the Contractor throughout construction. This spreadsheet shows outlet and patch panel port names, based upon the outlets shown on the Drawings, and is intended for the Owner’s use for patching and cross-connecting purposes during move-in.
2. The Contractor shall contact the Engineer prior to beginning construction to obtain an electronic copy for the Contractor’s use. Once the spreadsheet has been obtained, prior to beginning construction, the Contractor shall complete and verify the accuracy of the spreadsheet per the information shown on the Drawings.
3. The Contractor shall maintain the electronic copy of the spreadsheet with up-to-date as-built information on a minimum two-week interval throughout construction.
   a. The Contractor shall provide the Owner or Engineer an electronic copy of the up-to-date spreadsheet upon request during the course of construction.
   b. The Contractor shall be solely responsible for the completeness and accuracy of the spreadsheet throughout construction and upon delivery to the Owner and Engineer.
4. Pre-Substantial Completion: Three weeks prior to Substantial Completion, the Contractor shall submit the final version of the spreadsheet to the Owner and Engineer. The final version of the spreadsheet shall incorporate all as-built information and any changes from the original Drawings.

Station References Spreadsheet (Sample)

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Station Reference				Labeling												
Room Number	Room Description/Name	Station Number	Total Ports	Patch Panel Ports (by Station Port)						Station	Station Ports*					
				1	2	3	4	5	6		1	2	3	4	5	6
344	Open Office	1	3	344.1.1	344.1.2	344.1.3	-	-	-	344 - 3 - 1	1	2	3	-	-	-
344		2	3	344.2.1	344.2.2	344.2.3	-	-	-	344 - 3 - 2	1	2	3	-	-	-
345	Open Office	1	3	345.1.1	345.1.2	345.1.3	-	-	-	345 - 3 - 1	1	2	3	-	-	-
345		2	3	345.2.1	345.2.2	345.2.3	-	-	-	345 - 3 - 2	1	2	3	-	-	-
345		3	3	345.3.1	345.3.2	345.3.3	-	-	-	345 - 3 - 3	1	2	3	-	-	-
345		4	3	345.4.1	345.4.2	345.4.3	-	-	-	345 - 3 - 4	1	2	3	-	-	-
345		5	3	345.5.1	345.5.2	345.5.3	-	-	-	345 - 3 - 5	1	2	3	-	-	-
345		6	3	345.6.1	345.6.2	345.6.3	-	-	-	345 - 3 - 6	1	2	3	-	-	-
346		1	3	346.1.1	346.1.2	346.1.3	-	-	-	346 - 3 - 1	1	2	3	-	-	-
346		2	3	346.2.1	346.2.2	346.2.3	-	-	-	346 - 3 - 2	1	2	3	-	-	-
347	Work Area	1	3	347.1.1	347.1.2	347.1.3	-	-	-	347 - 3 - 1	1	2	3	-	-	-
348	Open Office	1	3	348.1.1	348.1.2	348.1.3	-	-	-	348 - 3 - 1	1	2	3	-	-	-
348		2	3	348.2.1	348.2.2	348.2.3	-	-	-	348 - 3 - 2	1	2	3	-	-	-
348		3	3	348.3.1	348.3.2	348.3.3	-	-	-	348 - 3 - 3	1	2	3	-	-	-
348		4	3	348.4.1	348.4.2	348.4.3	-	-	-	348 - 3 - 4	1	2	3	-	-	-
348		5	3	348.5.1	348.5.2	348.5.3	-	-	-	348 - 3 - 5	1	2	3	-	-	-
348		6	3	348.6.1	348.6.2	348.6.3	-	-	-	348 - 3 - 6	1	2	3	-	-	-
349	Copy/Print	1	2	349.1.1	349.1.2	-	-	-	-	349 - 3 - 1	1	2	-	-	-	-
349		2	3	349.2.1	349.2.2	349.2.3	-	-	-	349 - 3 - 2	1	2	3	-	-	-
349		3	2	349.3.1	349.3.2	-	-	-	-	349 - 3 - 3	1	2	-	-	-	-
350	Break	1	2	350.1.1	350.1.2	-	-	-	-	350 - 3 - 1	1	2	-	-	-	-
351	Open Office	1	3	351.1.1	351.1.2	351.1.3	-	-	-	351 - 3 - 1	1	2	3	-	-	-
351		2	3	351.2.1	351.2.2	351.2.3	-	-	-	351 - 3 - 2	1	2	3	-	-	-
351		3	3	351.3.1	351.3.2	351.3.3	-	-	-	351 - 3 - 3	1	2	3	-	-	-
351		4	3	351.4.1	351.4.2	351.4.3	-	-	-	351 - 3 - 4	1	2	3	-	-	-
351		5	3	351.5.1	351.5.2	351.5.3	-	-	-	351 - 3 - 5	1	2	3	-	-	-
351		6	3	351.6.1	351.6.2	351.6.3	-	-	-	351 - 3 - 6	1	2	3	-	-	-
352	Wireless Access	1	1	352.1.1	-	-	-	-	-	352 - 3 - 1	1	-	-	-	-	-
352	Open Office	2	3	352.2.1	352.2.2	352.2.3	-	-	-	352 - 3 - 2	1	2	3	-	-	-
353	Storage	1	2	353.1.1	353.1.2	-	-	-	-	353 - 3 - 1	1	2	-	-	-	-
353		2	2	353.2.1	353.2.2	-	-	-	-	353 - 3 - 2	1	2	-	-	-	-
353		3	2	353.3.1	353.3.2	-	-	-	-	353 - 3 - 3	1	2	-	-	-	-
354		1	3	354.1.1	354.1.2	354.1.3	-	-	-	354 - 3 - 1	1	2	3	-	-	-
354		2	3	354.2.1	354.2.2	354.2.3	-	-	-	354 - 3 - 2	1	2	3	-	-	-
361	Open Office	1	3	361.1.1	361.1.2	361.1.3	-	-	-	361 - 3 - 1	1	2	3	-	-	-
361		2	3	361.2.1	361.2.2	361.2.3	-	-	-	361 - 3 - 2	1	2	3	-	-	-
361		3	3	361.3.1	361.3.2	361.3.3	-	-	-	361 - 3 - 3	1	2	3	-	-	-
362		1	3	362.1.1	362.1.2	362.1.3	-	-	-	362 - 3 - 1	1	2	3	-	-	-
362		2	3	362.2.1	362.2.2	362.2.3	-	-	-	362 - 3 - 2	1	2	3	-	-	-
363	Open Office	1	3	363.1.1	363.1.2	363.1.3	-	-	-	363 - 3 - 1	1	2	3	-	-	-
363		2	3	363.2.1	363.2.2	363.2.3	-	-	-	363 - 3 - 2	1	2	3	-	-	-
364	Flr Box/Poke Thru	1	2	364.1.1	364.1.2	-	-	-	-	364 - 3 - 1	1	2	-	-	-	-
364	Wireless Access	2	1	364.2.1	-	-	-	-	-	364 - 3 - 2	1	-	-	-	-	-

Sample

END OF SECTION 271710

SECTION 271720 - COMMUNICATIONS - TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements for testing of the Communications Cabling System.

1.2 SUBMITTALS

A. Provide the following per the criteria set forth in Submittals in Division 27 Specification Section *Basic Communications Requirements*:
   1. Other:
      a. Testing (see *Part 2 – Testing* herein):
         1) Provide a list of proposed test equipment for use in verifying the installation of the communications cabling system.
            a) Provide for each testing device:
               i. Manufacturer and product number.
               ii. Manufacturer documentation showing date and outcome of last re-calibration. Testing device shall have been re-calibrated within the manufacturer's recommended recalibration period.
               iii. Manufacturer documentation showing software revision. Software revision shall be most current revision available for the device and shall be based upon the most current TIA testing guidelines.
               iv. Patch cords and other specialized components.
      b. Provide proposed test result forms.
      c. Provide the calculated optical fiber cable loss budget for each optical fiber cable in the system (see Part 3 – Execution: Testing herein)

PART 2 - MATERIALS

2.1 TESTING

A. General
   1. Testing of the systems shall be in accordance with the manufacturer's recommendations and with the Governing Requirements.
   2. Test reports shall be complete and in accordance with the appropriate Governing Requirements.
   3. Where testing discloses deficiencies in the work, the Contractor shall rework, repair, or replace equipment and systems found deficient. The Contractor shall continue remedial measures and retesting until satisfactory results are obtained. Remedial measures and retesting shall be at no additional cost to the Owner.
   4. Testing of product or equipment prior to installation shall include performance testing to establish the applicability of equipment for its intended purpose. The Contractor shall:

a. Establish the required test procedures from required Governing Requirements and manufacturer's recommendations.
b. Provide necessary test equipment, power, and consumables to perform the test.
c. Notify the Engineer of test schedule(s) at least one week in advance.
d. Perform test.
e. Provide test result documentation to the Engineer.

5. Final testing and start-up of product, equipment, and systems shall include establishing proper capacity, operation, maintenance, and compliance with Governing Requirements. The Contractor shall:
   a. Provide the services of manufacturer's representatives for systems to be tested and started up.
   b. Establish the required test procedures from required Governing Requirements and manufacturer's recommendations.
   c. Provide necessary test equipment, power, and consumables to perform the test.
   d. Notify the Engineer of test schedule(s) at least one week in advance.
   e. Perform tests and start-up functions.
   f. Provide documentation of test results and fully operational systems to the Engineer.
6. Test records shall be provided on a form approved by the Engineer.

B. Systems Specific: Test shall be performed for each of the following systems as follows:
1. Communications Cabling System
   a. Test records:
      1) Each cable in the system shall be tested. Test result forms shall include the cable identifier, tests performed, outcome of tests and indication of errors found, cable length, retest results, and name and signature of technician completing the tests. Test result forms shall be provided to the Owner and Engineer for review and acceptance.
      2) Test records for each cable within the system shall be printed directly from the tester and shall be submitted in paper form (in a binder) and on compact disk to the Owner and Engineer for review. Handwritten test results will not be accepted.
   b. Testing Devices: Testing devices shall be capable of storing and printing test records for each cable within the system.
      1) For copper cables:
         a) Testing device shall be a TIA TSB-95 Level 3 testing instrument re-calibrated within the calibration period recommended by the manufacturer, with the most current software revision based upon the most current TIA testing guidelines.
      2) For fiber cables:
         a) Testing devices shall consist of a light source/power meter with a stabilized light source for end-to-end attenuation testing and an Optical Time Domain Reflectometer (OTDR) for testing on the reel, for continuity and quality testing, for accurately determining cable length, and for locating and correcting problems noted during attenuation testing. Testing equipment shall be calibrated and traceable to the National Institute for Standards and Technologies (NIST), with an operating range of 850 +/- 30 nm or 1300 +/- 20 nm for multimode testing in accordance with TIA -526-14 for multimode testing, and an operating range of 1310 +/- 10nm or 1550 +/- 20 nm in accordance with TIA -526-7 for singlemode testing.

b) To ensure quality connectorization, a microscope of not less the 200x magnification shall be used to visually inspect connectors and splices after installation.

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section *Basic Communications Requirements*. Governing Requirements of particular relevance to this Section include, but are not limited to:
1. Testing:
a. TIA - 455: Fiber Optic Test Standards
b. TIA - 526: Optical Fiber Systems Test Procedures
c. TIA - 568 Commercial Building Telecommunications Cabling Standard
d. IEEE 802.3 (series): Local Area Network Ethernet Standard, including the IEEE 802.3z Gigabit Ethernet Standard

3.2 TESTING

A. General
1. Test devices shall be in calibration throughout the testing period. Tests performed on equipment without up to date calibration shall be rejected and shall be repeated at no additional cost to the Owner.
2. The Contractor shall notify the Engineer and Owner at least one week in advance of each type of test to be conducted. The Owner or Engineer may, at their discretion, witness all testing.
a. The Owner and Engineer shall be invited to attend and inspect the first instance of each type of test to be conducted. Tests conducted prior to first inspection shall be at the sole risk of the Contractor, and as such are subject to rejection. Such tests will be repeated at no additional cost to the Owner.

B. Systems Specific Testing:
1. Communications Cabling System
a. All interior (inside plant) and exterior (outside plant) fiber cables shall be tested on the reel upon delivery to the job site prior to installation.
1) Test results shall be permanently affixed to the reel and a copy given to the Owner and Engineer for review prior to installation.
2) Testing shall demonstrate compliance with the factory test results as shipped with the reel. Cables that fail to pass shall not be installed, and the Contractor shall replace the cable at no additional cost to the Owner. Repair of damaged cable is not acceptable.
b. Test the communications cabling system for compliance to the Governing Requirements and all applicable standards as follows:
1) Visually inspect all labels at the outlet locations (faceplates/ports), patch panels/ports, and on each end of each cable to ensure that all cables and equipment are correctly identified.

2) Copper Cable:
   a) For Horizontal Distribution: Test each copper horizontal cable, all pairs. To the extent possible, tests shall be performed with building electrical systems fully powered on (i.e. Lights, HVAC, etc.).
      i. Test each end-to-end Permanent Link (the entire link from the connector at the outlet to the connector or termination in the telecommunications closet) utilizing sweep tests, for Wire map (continuity), length, propagation delay/delay skew, attenuation (insertion loss), return loss, near-end cross talk (NEXT) loss, Equal Level Far-End Crosstalk (ELFEXT), attenuation-to-crosstalk ratio (ACR), power sum NEXT (PSNEXT) and power sum ELFEXT (PSELFEXT). Each cable shall be tested in both directions.
      ii. Test results shall demonstrate compliance with:
         (1) The criteria specified in TIA 568 for Category 6A cables
         (2) The criteria specified in IEEE 802.3z (1000Base-X Gigabit Ethernet)
   b) For Backbone Distribution (inside and outside plant): Test each cable, all pairs, for length, shorts, opens, continuity, polarity reversals, transposition (wire map), and the presence of AC voltage.
      i. Test entire channel, from termination block to termination block.
      ii. Test results shall demonstrate compliance with:
         (1) The criteria specified in TIA 568 for Category 3 cables
3) Fiber Cable:
   a) Prior to testing, the cable loss budget shall be calculated by the Contractor for each optical fiber cable and shall be clearly shown on the test documentation. Maximum loss shall be calculated by the following formula, assuming no splices:
      i. For Horizontal Distribution:
         (1) Max Loss = 2.0db (per TIA 568A Annex H)
      ii. For Backbone Distribution (inside and outside plant):
         (1) Max Loss = (allowable loss/km) * (km of fiber) + (0.4db) * (# of connectors)
         (2) A mated connector-to-connector interface is defined as a single connector for the purposes of the above formula.
      iii. A given fiber cable shall not exceed its calculated maximum loss (per the above formula).
   b) Test all strands. Testing shall consist of a bi-directional end-to-end Optical Transmission Loss Test Instrument trace performed per TIA 455-61 and a bi-directional end-to-end power meter test performed per TIA 455-53A.
      i. Loss numbers shall be calculated by taking the sum of the two bi-directional measurements and dividing that sum by two.
      ii. All backbone fiber cables shall be tested with an OTDR in addition to attenuation testing performed with a power meter.
         (1) The number of samples (averages) for each OTDR test shall be such that the noise amplitude is significantly less than the smallest loss of any component under test.
      iii. Multimode fiber testing shall incorporate use of a mandrel wrap of fiber jumper to induce macro bends in the fiber.

c) Test measurements shall be provided as follows:
   i. For Multimode Cable: Test at both 850 and 1300nm.
   ii. For Singlemode Cable: Test at both 1310 and 1550nm.
d) Test results shall demonstrate compliance with:
   i. The criteria specified in TIA-568A Annex H.
   ii. The Contractor's calculated loss budget above.
   iii. The criteria specified in IEEE 802.3z (1000Base-X Gigabit Ethernet)

c. In addition to the above, tests performed shall be both those recommended and mandated by the communications cabling system Manufacturer.

d. Cables and equipment that do not pass shall be identified to the Engineer. The source of the non-compliance shall be determined, corrected or replaced, and re-tested at no additional cost to the Owner. Provide new test results to the Engineer in the same manner as above.
   1) In addition to the above, if it is determined that a cable is at fault, the contractor shall remove the damaged cable and replace it with a new cable. Cable "repairs" are not acceptable. The procedure for removing the cable shall be as follows:
      a) Prior to removal of the damaged cable and re-pull of the new cable:
         i. Any cables which are in the same conduit, duct or innerduct as the damaged cable shall be tested, regardless of whether or not they are new cables installed as part of this project or existing cables installed prior to this project.
         ii. If the damaged cable is a backbone or outside plant cable:
            (1) The Owner and Engineer shall be informed of the schedule for the removal and re-pull.
            (2) The new cable shall be tested on the reel prior to installation.
         iii. All test results shall be provided to the Engineer for approval.
      b) The damaged cable shall be removed and the new cable shall be pulled in.
      c) After the removal of the damaged cable and re-pull of the new cable:
         i. The new cable shall be tested.
         ii. Any cables which are in the same conduit, duct or innerduct as the damaged cable shall be tested, regardless of whether or not they are new cables installed as part of this project or existing cables installed prior to this project.
         iii. All test results shall be provided to the Engineer for approval.
      d) Existing cables which are in the same conduit, duct or innerduct as the damaged cable, and which are damaged by the extraction and re-pull process, shall be removed and replaced at no additional cost to the Owner.
         i. Existing damaged cables that are replaced shall be subject to the testing procedures of this Section in its entirety.

END OF SECTION 271720

SECTION 280000 - SECURITY GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies the general requirements for Security Systems.

B. Provide all labor, materials, equipment, tools and services required for the installation of the Security Systems.

C. Contractor personnel assigned to device programming and hardware/software installation shall have been certified in these tasks by the Manufacturer or possess industry certifications acceptable to the Manufacturer and the Owner attesting to the necessary competence.

1.2 RELATED SECTIONS

A. Division 8 Specification Section 08 71 00 *Door Hardware*. Provide coordination as required to support the work of this Section.

B. Division 27 Specification Section 27 00 10 *Basic Communications Requirements*. Provide cabling coordination as required to support the work of this Section.

C. Division 27 Specification Section 27 04 05 *Common Work - Sleeves, Penetrations and Firestopping*. Provide sleeves, penetrations, and firestopping as required to support the work of this Section.

D. Division 27 Specification Section 27 04 06 *Common Work – Hangers and Supports*. Provide hangers and supports as required to support the work of this Section.

E. Division 27 Specification Section *Public Address - General Requirements*. Provide integration with the Public Access System as required to support the work of this Section.

1.3 SUBMITTALS

A. Provide the following per the criteria set forth in Submittals in Division 27 Specification Section 27 00 10 *Basic Communications Requirements*:
   1. Product Data
   2. Shop Drawings

1.4 RECORD DOCUMENTS

A. Provide Record Documents per the criteria set forth for Record Documents in Division 27 Specification Section 27 00 10 *Basic Communications Requirements.*

1.5 OPERATION AND MAINTENANCE MANUALS

A. Provide Operation and Maintenance Manuals per the criteria set forth for Operation and Maintenance Manuals in Division 27 Specification Section 27 00 10 *Basic Communications Requirements*.

1.6 WARRANTY

A. Provide warranty support per the criteria set forth for Warranty in Division 27 Specification Section *27 00 40 Warranty*.

1.7 TRAINING

A. Provide system training per the criteria set forth for Training in Division 27 Specification Section *27 00 60 Training*.

PART 2 - MATERIALS

2.1 GENERAL

A. Plenum Rating:
   1. Cable shall be plenum rated unless otherwise indicated. Cable shall bear plenum markings.
   2. Supports, incidental materials, cable ties and cable retainers shall be plenum rated to match that of associated cable.

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section 27 00 10 *Basic Communication Requirements*. Governing Requirements of particular relevance to this Section include, but are not limited to:
   1. IBC: International Building Code
   2. IEEE C62.41: Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits
   3. IEEE 802.1x: Standard for Port Based Network Access Control
   4. NFPA 72: National Fire Alarm and Signaling Code
   5. NFPA 731: Standard for the Installation of Electronic Premises Security Systems
   6. NFPA 101: Life Safety Code
   7. UL 294: Standard for Access Control System Units
   8. UL 497B: Protectors for Data Communications and Fire-Alarm Circuits
   9. UL 1449: Transient Voltage Surge Suppressors
   10. UL 2900-2-3: Outline of Investigation for Software Cybersecurity for Network-Connectable Products, Part 2-3: Particular Requirements for Security and Life Safety Signaling Systems

3.2 SOFTWARE IMPLEMENTATION

A. The Contractor shall provide all software configurations as required to provide a fully functional and operating system ready for the Owner's use. Software configuration shall include but not be limited to Cybersecurity, encryption, firmware, data communication, operating system settings, manufacturer approved installation practices. Existing Security Systems shall be incorporated into new/expansion systems, as required.

3.3 HARDWARE CONFIGURATION

A. The Contractor shall provide all hardware configurations as required to provide a fully functional and operating system ready for the Owner's use. Hardware configuration shall include but not be limited to Cybersecurity configuration, data communication, system settings, power distribution and manufacturer approved installation practices. Existing Security Systems shall be incorporated into new/expansion systems, as required.

3.4 INSTALLATION

A. Pathways: Prior to the installation of Security Systems cabling, Contractor shall verify conduit sizing and quantity for correctness. Deviations from the design documents shall be documented and Contractor shall contact Engineer with notification of deviation.

B. Cabling:
   1. Security Systems cabling that is not network-based (i.e. Category 5E, 6, etc.) shall maintain separation from other system cabling and shall route within dedicated Security System pathways.
   2. Cable pulls shall be conducted within the following requirements:
      a. Manufacturer's guidelines for pulling tension and bend radii.
      b. NEC conduit fill standards. Contractor shall notify Engineer prior to cable installation when conduits are found to be undersized.
      c. Any cable found to be faulty due to poor cable installation practices shall be removed and replace at no additional cost to Owner.
   3. Cable splicing shall not be considered a common installation practice. If necessary, splice cables only in junction boxes or racks. Shielded cables shall not be spliced; instead each end shall be terminated with an appropriate connector to maintain shield continuity. Any cable found to be faulty due to splicing shall be removed and replaced at no additional cost to Owner.
   4. The Contractor shall dress all cables at both ends with:
      a. Black heat shrink where jacketing has been stripped away to expose individual conductors
      b. Clear heat shrink where shields have been exposed (Coax excluded)
      c. Printed, adhesive labels with clear heat shrink over each label
   5. Contractor shall make all terminations with rosin-core solder, crimp/compression type connectors or captive screw type mechanical connections. For captive screw type mechanical connection, use spade type or ferrules type crimp terminations. Bare wire terminations are not acceptable.

C. Equipment:
   1. Equipment shall be installed as indicated and specified, and in accordance with the manufacture's recommendations, except where local codes or regulations take precedence.
   2. Place equipment labels or other identification where the label or identification can be easily seen and read without difficulty.
   3. Equipment shall be installed level, plumb, parallel, and perpendicular to building structures and to other building systems and components, except where otherwise indicated.
   4. Equipment shall be securely fastened. Select fasteners and supports so that the load applied to any one fastener maintains a minimum load factor of five.
   5. Equipment locations: Prior to installation of Security System equipment, Contractor shall coordinate with other trades and subsequently verify all equipment locations that mount on walls or within ceilings. This shall include but not be limited to:
      a. Structural elements such as lighting devices, HVAC equipment, fire protection devices, and cable tray
      b. Structural support elements for ceiling mounted devices
      c. Backing Board for wall mounted devices
   6. Prior to head-end equipment installation, contractor shall verify equipment rooms are and will remain free of airborne contaminants.
   7. After head-end equipment installation, contractor shall protect equipment from any future construction work that could cause damage to equipment, i.e. masonry, wood, paint, plumbing, etc.
   8. Prior to furniture work, Contractor shall coordinate with other trades and subsequently verify all equipment locations that mount within furniture.
   9. Contractor shall coordinate with architect as to any equipment color and finish requirements.
   10. Any equipment exposed to tampering or indicated as tamper or vandal proof shall be installed with tamper/vandal proof enclosures and secured using pin-head Torx fasteners suitable for the material and load requirements.

D. Software:
   1. Contractor personnel shall comply with all applicable state and local licensing requirements.
   2. Contractor personnel assigned to device programming and software installation shall have been certified in these tasks by the Manufacturer or possess industry certifications acceptable to the Manufacturer and the Owner attesting to the necessary competence.
   3. Installers shall follow all recommended procedures and guidelines from the Manufacturer to securely provision network connected products.
   4. The Contractor and its authorized installers shall:
      a. Follow an Owner-approved password provisioning plan
      b. Complete the owner-approved asset management worksheet to include:
         1) Manufacturer, model, and firmware or software version
         2) Serial number and MAC address, if applicable
         3) Network settings, including IP address, VLAN or subnet mask, default gateway
         4) Equipment locations shall be coordinated with the Owner
         5) Device user names and passwords (Alternatively, if the worksheet is not protected, user names and passwords should be provided via a secured means to the Owner)

c. All security device passwords shall be changed from default and follow strong enforcement standards approved by the Owner
d. Synchronize security devices with a common time base acceptable to the Owner
e. Disable all services and ports not required for ongoing system operation
f. Provision device and system privileges in a manner approved by the Owner

E. Grounding and Surge Protection:
1. The Contractor shall follow accepted engineering practices when installing the Security Systems grounding system. The security grounding system installation shall conform to NEC standards. The contractor shall be responsible for correcting any grounding problems within the Security System including but not limited to electromagnetic/electrostatic interference, ground loops anomalies, and distortions.
2. All devices installed to the exterior of structure shall be protected from surge voltages with surge suppression devices. Install surge suppression devices in strict accordance with the manufacturer requirements.
3. All solenoid or coil driven devices (i.e. door strikes, pin bolt locks, large relays, gate operators and magnetic locks) shall be installed with metal oxide varistors for surge suppression.

F. Structural Installations
1. Structural support elements are defined as those materials added to structure for the reinforcement of general construction methods to meet a designed minimum load factor of five. These include but are not limited to:
a. Backing boards required for the support of Security System equipment and cabling
b. Strut supports hung from structural beams or concrete slab
2. It is the Electrical Contractor's responsibility to provide structural support elements for the Security Systems equipment.
3. The Contractor is to provide all Security Systems mounting and rigging equipment that fasten to the structural support elements.
4. All support elements and fastenings shall be able to support a minimum load factor of five times the total assembled weight of the Security System equipment.
5. The Contractor shall be responsible for the complete and correct installation of all Security Systems equipment.

3.5 TESTING

A. Operational Testing
1. Prior to system training and acceptance testing, the Contractor shall perform and document operational testing.
a. Access Control System
1) Contractor shall assemble the following test equipment:
a) Ground fault indicator
b) Digital Multi-meter
2) Prior to any connections being made to building power, Contractor shall use a ground fault indicator to verify the circuits are properly grounded wiring. If grounding is found to be faulty, the contractor shall notify the electrical contractor. Connections shall not be made to building power until proper grounding is demonstrated.

3) The Contractor shall produce a checklist for testing and documentation of all Access Control System equipment. Each device shall be verified for proper operation at the monitoring stations and the door locations. Devices under test shall consist of, but not be limited to card readers, locking mechanisms, door position switches, request to exit devices, auto operators, handicap paddles, crash bars with switches, and overhead door operators.
4) The Contractor shall correct any defective device upon discovery. The Contractor shall notify and coordinate with other trades as necessary to ensure faulty devices are put into working order.
5) The Contractor shall test and document all "end of line resistance" values in all states of operation, where applicable. Correct any defect upon discovery.
6) The Contractor shall test and document all data transmissions for proper operation. Correct any defect upon discovery.
7) The Contractor shall conduct operational testing, in accordance with manufacturer approved test recommendations.

B. Acceptance Testing
1. System acceptance testing shall not be conducted until all final "as-built" drawings, manuals and operational testing have been completed and the documentation has been submitted for Engineer's review.
2. Acceptance testing shall be conducted with Contractor, Engineer, and Owner in attendance.
3. Contractor shall demonstrate that all components of the Security System are in proper working order and are in accordance with specifications.
4. For systems requiring battery standby power, a battery test shall be automatically performed to test the standby battery integrity. The test shall disconnect the standby battery from the charging circuit and place a load on the battery per UL requirements.
5. At time of acceptance testing, all items found to be outside of specification requirements; Owner requirements, code requirements or general installation practices shall be added as new items to the final Punch List. All items found outside of specification requirements shall be put into working order prior to final acceptance of system.
6. The Contractor shall assemble an inventory of installed equipment. This inventory shall be compiled at time of acceptance testing and compared to equipment listed in contractual documents.
7. Acceptance testing may be suspended by Engineer if Security Systems are not complete and operable, equipment failure occurs, or installation is not in accordance with specifications. Contractor shall be responsible for any cost incurred by Engineer for additional site visits required to complete acceptance testing.
8. In conjunction with the Owner's IT Department, the Contractor shall arrange for a post-installation vulnerability test to verify that additional cyber vulnerabilities have not been introduced into the Owner's network as a result of this project.

END OF SECTION 280000

SECTION 281000 - SECURITY - ACCESS CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. This Section defines the Security System requirement for the Access Control System.

1.2 RELATED SECTIONS

A. The requirements of Division 28 Specification Section *Security - General Requirements* shall serve as the basis for the requirements of this Section and are incorporated by reference into this Section.

1.3 SUBMITTALS

A. Provide the following per the criteria set forth for Submittals in Division 28 Specification Section Basic Requirements:
   1. Product Data
   2. Shop Drawings

1.4 SYSTEM DESCRIPTION

A. Summary: The new Access Control System within this facility shall be an extension of the existing City of Greeley Fire Station Access Control System. All system components of the new Access Control System shall be compatible with the existing system. The new Access Control System head-end equipment shall reside within this facility and communicate with the existing Access Control System database via the Owner's data network. The Security Contractor shall provide a fully functional and operating system ready for the Owner's use. The Security Contractor shall coordinate with the Owner for system integration requirements including but not limited to: compatibility, connectivity, database software upgrades and software configurations.

B. The Access Control System shall interface with other systems within the facility. Systems shall interface through hardware connectivity including but not limited to network / serial communication, contact closure and voltage / ground reference. The Security Contractor shall closely coordinate with other trades to ensure a fully functional, operating and integrated system ready for the Owner's use. The Access Control System shall interface with the following systems:
   1. Intercom System: <Provide monitoring of intercom station communication.
   2. Fire Alarm System: The Access Control System shall interface with the Fire Alarm equipment (through relay activation provided by the Fire Alarm Contractor) in the event of a fire alarm. The Security Contractor shall coordinate the functionality of the Access Control System during the activation of the fire alarm with Authorities Having Jurisdiction, Fire Alarm Contractor, and the Owner.

C. The Security Contractor shall provide all Access Control System cabling to provide a fully functional and operating system ready for Owners use with the exceptions of the following requirements:
   1. Network Cabling: The Access Control System within this facility shall be a centrally distributed system with control panel residing on the main level. The Telecommunication Contractor shall provide the network cabling to the security panel as required. The Access Control Contractor shall coordinate with the Telecommunications Contractor for cabling requirements.

D. The primary function of the Access Control System is to secure / monitor selected building entry locations from unauthorized entry. The Access Control System shall include but not be limited to a database application(s), access control processing equipment, communication equipment, verification devices, a monitoring station(s), power supplies, any necessary cabling and door hardware equipment to provide a fully functional and operating system ready for the Owner's use.
   1. The new extension to the existing Access Control System resides locally within this facility. The existing Database software shall be upgraded and reconfigured as required to incorporate the addition of the new Access Control System requirements. The Security Contractor shall provide all modifications to the existing system required to provide a fully functional and operating system ready for the Owner's use, including but not limited to:
      a. Software:
         1) Access Control System software: Software require for the direct operation of the local Access Control System head-end equipment.
         2) Server operating system software: Server operating system software and/or upgrades required to expand the current database.
         3) Database modifications: Database modifications required to incorporate the addition of the new Access Control System, which shall include but not limited to: programming, troubleshooting, testing and verification of system operation.
         4) Software modifications: Software modifications required to incorporate the addition of the new Access Control System, which shall include but not limited to: programming, troubleshooting, testing and verification of system operation.
         5) Software upgrades: Software upgrades required to incorporate the additions of the new Access Control System. Software upgrade package shall be valid for the duration of the warranty period. The Security Contractor shall purchase the software upgrade package in the Owner's name and provide documentation and renewal information to the Owner at acceptance testing. The Security Contractor shall install all software upgrades in a timely manner upon availability.
         6) Software licenses: Software licenses required to incorporate the additions of the new Access Control System including but not limited to:
            i. Site license
            ii. Client licenses
      b. Hardware:
         1) Head-end equipment: Equipment required for the direct operation of the Access Control System.
         2) Server equipment modifications: Server equipment modifications required for the Access Control System database operation.
         3) Network switches: Switch equipment shall be provided by Owner.

c. The Access Control System shall be capable of stand alone operation in the event that communication is interrupted between the local system and the Network Database.

d. The head-end Access Control System equipment (to include Panels and Servers) shall have battery back-up power for a minimum of 1 hour of continued operation of the entire system in the event of a power outage. This does not apply to lock power supplies unless specifically required.

e. The Access Control System shall provide monitoring of the facility to include but not be limited to:
   1) Events within standard door operation: the following actions shall occur upon a valid card read:
      a) Door alarm shall be shunted and return to alarmed state after door closure.
      b) An icon on a graphical map shall indicate a valid entry.
      c) Card holder information shall display at all Monitoring Stations, as applicable.
      d) Card holder information shall register within an events log.
   2) Events outside of standard door operation: the following actions shall occur upon an unsecure status including but not limited to force open, hold open and latch obstruction situations:
      a) A visual / audible notification shall display at all Monitoring Station, if applicable.
      b) An icon on a graphical map shall indicate an invalid entry and notify personnel of alarm.
      c) The event shall register within an events log.

f. The Security Contractor shall provide connectivity to all door hardware, as applicable, to ensure the Access Control System operates within the parameters set forth herein. The Security Contractor shall provide door hardware as specified in the Product section herein. All other door hardware shall be provided by others. The Security Contractor shall coordinate with Door Hardware Contractor to ensure all door hardware operates as indicated in Construction Documents. The Access Control System shall provide operation for doors consistent with but not limited to the following:
   1) Secured side access:
      a) The door shall remain locked to unauthorized personal at all times except during times of building operation. Coordinate building operation schedule with Owner.
      b) Authorized personnel shall present badge to card reader unit, upon database verification, access shall be granted. The automatic door opener feature, if applicable, shall be available only after personnel are granted access. The door shall remain unsecured for Owner determined number of seconds before returning to a secure state.
      c) Fail Secure doors shall remain secure in the event of a power outage, unless determined otherwise.
   2) Unsecured side access:
      a) The door shall provide free egress from building at all times.
      b) Egress shall be provided by means of a mechanical release located within the door hardware (non-magnetic locks) or an electromechanical switch located within door handle, exit device or door frame (magnetic locks).

c) The automatic door opener feature, if applicable, shall be available at all times.

PART 2 - MATERIALS

2.1 GENERAL

A. Manufacturer: Unless otherwise indicated, equipment in this Section shall be the standard products of a manufacturer regularly engaged in the manufacture of such products. All components used in the system shall be commercial designs that comply with the Specifications. Each major component of equipment shall identify the manufacturer's name, model and serial number. Items of the same classification shall be identical. This includes equipment, modules, parts, and components. The Engineer retains the right to reject products which reflect, in the Engineer's opinion, sub-standard design practices, manufacturing procedures, support services, or warranty policies.
   1. Unless otherwise indicated, the equipment by the following manufacturers shall not be substituted. The Security Contractor shall provide the most current model and/or version of product available by listed manufacturer at time of procurement:
      a. Brivo ACS OnSite

B. Equipment Schedule(s): The equipment schedule(s) on Drawings is general in nature and is provided to define system requirements, including but not limited to: functionality, signal compatibility, mounting requirements, space requirements, cooling requirements and overall clarity / intent of operation. The equipment schedule(s) is not all inclusive and is not to be used as a bill of materials. The Security Contractor shall provide all equipment required for a fully functional and operating system ready for the Owner's use that may or may not be explicitly specified within Construction Documents.
   1. Part Numbers: Refer to the equipment schedule(s) for specific part numbers. Part numbers listed in the equipment schedule(s) define the performance specifications for the parts and shall be per the most recent manufacturer's cut/data specification sheets available at the time of bid. If no part number is provided, then any part meeting the functional and operational requirements specified is acceptable.
   2. Provide materials in quantities as required to provide a fully functional and operational System.
   3. Owner Furnished Contractor Installed (OFCI): Refer to the equipment schedule(s) on Drawings for procurement requirements. Equipment identified as "OFCI" shall be provided by Owner for the Security Contractor to install.

2.2 EQUIPMENT SPECIFICATIONS

A. This equipment shall as a minimum conform to the following specifications:
   1. Access Control Processing Equipment
      a. The access control processing equipment shall provide capacity for current door requirements as referenced in drawings with the ability to expand for future Access Control needs.
      b. The processing equipment shall have a dedicated Class II power supply with battery charger

c. Security Contractor to verify power requirements of processing equipment prior to installation and shall include battery calculations for standby power in design submittals.

2. Card Reader
   a. The card reader shall be a proximity type card reader.
   b. The card reader shall have battery backup power in the event of power outages.
3. Lock Power Supply
   a. The lock power supply shall be a dedicated, voltage selectable Class II power supply with battery charger capable of providing power to multiple door locks (typically 8 or 16).
4. Reader Interface
   a. The Reader Interface shall provide inputs for card readers, door positions and request to exit switches.
   b. The Reader Interface shall provide outputs for lock controls and alarm closures.
   c. The Reader Interface shall communicate with the access control processing equipment via a data signal type protocol.

2.3 POWER DISTRIBUTION

A. The Security Contractor shall provide all power distribution equipment required to provide a fully functional and operating system ready for the Owner's use. Power distribution equipment shall include but not be limited to; power conditioners, surge suppressors, Uninterruptable Power Supplies (UPS), power strips, power cords and power cabling.
   1. Power distribution equipment may or may not be indicated in drawings and/or specifications.
   2. Power distribution equipment indicated within drawings and/or specifications are shown for specific implementation, isolation from other uses, or general clarification.
   3. Power distribution equipment shown within drawings and/or specifications does not represent the power distribution equipment in its entirety, the Security Contractor shall provide remaining power equipment as required to provide a fully functional and operating system for the Owner's use.

2.4 WIRE AND CABLE

A. This equipment shall as a minimum conform to the following specifications. Cable gauge and conductor quantity requirements may vary depending on device requirements. The Security Contractor to determine and utilize cable with proper conductor and gauge requirements to provide proper operation.
   1. Refer to the associated Equipment Schedule on the Technology Construction Drawings for all wire and cable requirements.
   2. Access Control cabling shall be yellow composite plenum consisting of a 22-6 shielded, 22-4 unshielded, 18-4 unshielded and a 22-2 unshielded.

PART 3 - EXECUTION

3.1 GENERAL

A. The Security Contractor shall closely coordinate with the Owner to ensure that Owner provided equipment is procured, configured (as necessary), and installed (as necessary) with ample lead time prior to the Security Contractor's use of the equipment.

B. The Security Contractor shall closely coordinate with the Authority Having Jurisdiction to ensure that all local codes and building requirements are met. The Security Contractor shall provide all documentation required for permitting and to pass Certificate of Occupancy.

C. Refer to Division 28 Specification Section - *Security General Requirements* for execution requirements.

END OF SECTION 281000

SECTION 283111 - FIRE DETECTION AND ALARM

PART 1 GENERAL

1.1 SUMMARY:

A. Extent of fire alarm systems work is indicated by drawings, schedules, and riser diagrams. Drawings show general intent, not necessarily every device, wiring and component necessary for a complete system. The contractor shall be responsible for a complete operational system.

B. Provide system suitable for type and occupancy as defined by local Building Code and as approved by local Fire Marshal. Provide type of system acceptable to the local Fire Marshal.

C. The system to be provided shall be an Analog/Addressable System which is defined as a system in which initiating devices and interface modules transmit their address via a binary or multiplex code over a common pair of wires. This address is converted to an English language display giving a custom description for each reporting device. In addition, the system will provide analog information about the sensitivity of each ionization, photoelectric, and heat sensing device. The system control panel will maintain a log of this information which can be reviewed on demand. The system will also provide a maintenance alert when the sensitivity of any detector has been outside of a preset range for a period of 24 hours.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of fire alarm systems of types, sizes, and electrical characteristics required, and whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firm with at least 5 years of successful installation experience on projects with fire alarm systems work similar to that required for this project.

1. Firm with manufacturer's factory trained personnel.
2. Firm with factory authorized service organization and spare parts stock within 50 miles of the project and with a 24 hour response time.

C. Codes and Standards

1. Each and every item of the fire alarm system shall be listed as the product of a single fire alarm system manufacturer under the appropriate category by Underwriters Laboratory, Inc. (UL) and shall bear the UL label on all devices, appliances and panels comprising the system. All control equipment shall be listed under the category UOJZ as a single control unit and cross listed with the base loop fire alarm system. Partial listings shall be unacceptable.

2. The complete installation shall conform to the applicable sections of NFPA and Local Code Requirements, and the National Electrical Code with particular attention to article 760. All control equipment must have transient protection to comply with UL 864 requirements or Standard #497B as applicable.

3. FM Compliance: Provide fire alarm systems and accessories which are FM approved.

4. The fire alarm system and devices shall comply with ADA 1990 and UL 1971 requirements.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data including specifications, data sheets, wiring diagrams, equipment ratings, dimensions, finishes, and description of system operation.

B. Shop Drawings: Provide shop drawings showing system components, including panels and cabinets, locations, quantities, and full schematic of system wiring showing conductor routings and quantities, and connection details. Provide updated room names and numbers that match the names and numbers as labeled at the building. Room names and numbers shown on the contract documents are not necessarily those that are currently being used in the building. The fire alarm manufacturer shall coordinate with the contractor and owner on existing and new work and survey the site on existing work to identify the proper names and numbers. All conduit routing must be submitted to, and accepted by, the Architect/Engineer. Shop drawing documents must be submitted simultaneously with sprinkler system documents and prior to installation.

This information shall be submitted on 1/8 inch = 1foot scale building floor plans. No other systems shall be included on these plans. Reproduction of contract drawing will not be acceptable. The following information shall be included in the shop drawings:

1. Occupancy group and use.
2. Number of stories.
3. Indicate extent of building sprinkler system.
4. Indicate addition to/modifications of existing system.
5. One-line diagram showing/indicating number of devices and appliances per zone/circuit.
6. Wire sizes, color coding, type(s) and voltage drop calculations.
7. Indicate annunciation method and include graphic zone map.
8. Addition to or modification of the system shall be distinguishable from the existing and be identical on the floor plans as well as the one-line diagram(s).

C. Submit manufacturer's installation instructions, including outlet or back box requirements for each piece of equipment.

D. Submit manufacturer's certificate that system meets or exceeds specified requirements.

E. Submit sequence of operation and verification of system operation by manufacturer or his authorized representative.

F. Submit back-up battery calculations.

G. All shop drawings, battery and voltage drop calculations shall be submitted to the authority having jurisdiction for review after review by the Architect/Engineer.

H. Submit three copies of test results and data to Architect/Engineer no later than seven days after conclusion of tests described in this section.

I. Submit graphic annunciator and/or map layouts for review by the Architect/Engineer prior to fabrication.

J. Indicate whether fire alarm system is required or non-required and list code sections required by and applicable to.

K. List all variances and attach as required.

L. Include brief description of scope of work.

M. Submit Zone schedule.

N. Maintenance Data: Submit maintenance data and parts lists for each type of fire alarm equipment installed, including furnished specialties and accessories. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 1.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Handle fire alarm equipment carefully to prevent damage, breaking, and scoring. Do not install damaged equipment or components; replace with new.

B. Store fire alarm equipment in clean, dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

1.5 EXTRA MATERIALS:

A. General: Provide extra materials as listed below in addition to that required to complete the work. The additional stock shall not be used unless specifically authorized by the Owners Representative.

B. Lamps: Furnish spare/replacement lamps and LED's amounting to not less than three (3) lamps of each type and of each color.

C. Devices:

1. Furnish spare/replacement detection bases amounting to 5 percent of the quantity installed by this work, but not less than two (2) of each type, including duct detector housings.

2. Furnish spare/replacement detectors amounting to 10 percent of the quantity installed by this work, but not less than two (2) of each type.

3. Furnish spare/replacement adaptor modules and relays amounting to 5 percent of the quantity installed by this work, but not less than one (1) of each type.

4. Furnish spare/replacement speakers/horns, combination speaker/horn/strobe units, and strobe units amounting to 5 percent of the quantity installed by this work but not less than one (1) of each type.

1.6 OPERATION:

A. The system alarm operation subsequent to the alarm activation of any manual station, automatic detection device, or sprinkler flow switch shall be as follows:

1. All audible alarm indicating appliances shall sound a distinctive and continuous fire alarm signal until silenced by the alarm silence switch at the control panel or at the remote annunciator.

2. All visible alarm indicating appliances shall flash continuously until the system is reset. Visual alarm devices shall continue to operate when audible devices are silenced. Any subsequent zone alarm shall reactivate the alarm indicating appliances.

3. All doors normally held open by door control devices shall release.

4. A supervised signal to notify the monitoring center shall be activated. Signal shall indicate separately, a fire detector zone in alarm, fire alarm system trouble, sprinkler tamper (supervisory), sprinkler flow OR individual alarm point address and description, including system troubles and other monitored signals.

5. Activation of a sprinkler flow device shall cause the exterior horn/light to operate continuously until the flow has ceased.

B. The alarm shall be displayed on an 80 character LCD display. The top line of 40 characters shall be the point label and the second line shall be the device type identifier. The system alarm LED shall flash on the control panel and the remote annunciator until the alarm has been acknowledged. Once acknowledged, this same LED shall latch on. A subsequent alarm received from another zone shall flash the system alarm LED on the control panel and remote annunciator. The LCD display shall show the new alarm information.

C. A pulsing alarm tone shall occur within the control panel until the event has been acknowledged.

D. The alarm activation of any elevator lobby, top of shaft, bottom of shaft, or elevator equipment room smoke detector shall, in addition to the operations listed above these cause the elevator cabs to be recalled according to the following sequence:

1. If the alarmed detector is on any floor other than the primary level of egress, the elevator cabs shall be recalled to the primary level of egress.

2. If the alarmed detector is on the primary egress level, the elevator cabs shall be recalled to the predetermined alternate recall level as determined by the local authority having jurisdiction.

3. If the alarmed detector is located in the elevator shaft it shall cause the shaft ventilation damper to open in addition to recalling the elevator.

E. The activation of any thermal detector located in the elevator equipment room, top of shaft, or bottom of shaft shall cause the power to the elevator equipment and power to all lighting and receptacles in the equipment room to be disconnected from their source.

F. The activation of any system addressable smoke detector shall initiate an Alarm Verification operation whereby the panel will reset the activated detector and wait for a second alarm

activation. If within one (1) minute after resetting, a second alarm is reported from the same or any other smoke detector, the system shall process the alarm as described previously. If no second alarm occurs within one minute the system shall resume normal operation. The Alarm Verification shall operate only on addressable smoke detector alarms. Other activated initiating devices shall be processed immediately. The alarm verification operation shall be selectable by zone.

1. The control panel shall have the capability to display the number of times (tally) a zone has gone into a verification mode. Should this mode verification tally reach a pre-programmed number, a trouble condition shall occur.

G. The control panel shall have a dedicated supervisory service LED and a dedicated supervisory service acknowledge switch.

1. The activation of any standpipe or sprinkler valve supervisory (tamper) switch shall activate the system supervisory service audible signal and illuminate the LED control panel and the remote annunciator. Differentiation between valve tamper activation and opens and/or ground on the initiation circuit wiring shall be provided.

2. Pressing the Supervisory Service Acknowledge Key will silence the supervisory audible signal while maintaining the Supervisory Service LED "ON" indicating the off-normal condition.

3. Restoring the valve to the normal position shall cause the Supervisory Service LED to extinguish, indicating restoration to normal.

H. A manual evacuation (drill) switch shall be provided to operate the alarm indicating appliances without causing other control circuits to be activated. However, should a true alarm occur, all alarm functions would occur as described previously.

I. The system shall have a single key that will allow the operator to display all alarms, troubles, and supervisory service conditions including the time of each occurrence.

J. All doors normally held open by door control devices shall release upon AC power failure.

K. The actuation of the "enable walk test" program at the control panel shall activate the "Walk Test" mode of the system which shall cause the following to occur:

1. The city circuit connection shall be bypassed.
2. Control relay functions shall be bypassed.
3. The control panel shall show a trouble condition.
4. The alarm activation of any initiation device shall cause the audible signals to code a number pulses to match the zone number.
5. The panel shall automatically reset itself after signaling is complete.
6. Any momentary opening of an initiating or indicating appliance circuit wiring shall cause the audible signals to sound for 4 seconds indicating a trouble condition.
7. The system shall have the capacity of 8 distinctive walk test groups. Such that only a portion of the system need be disabled during testing.

1.7 SUPERVISION:

A. There shall be supervisory service initiation device circuits for connection of all sprinkler valve supervisory (tamper). Device activation shall cause a supervisory alarm at the control panel.

B. There shall be independently supervised and independently fused indicating appliance circuits for alarm speakers and flashing alarm lamps. Disarrangement conditions of any circuit shall not affect the operation of other circuits.

C. Auxiliary manual control shall be supervised so that an "off normal" position of any switch shall cause an "off normal" system trouble.

D. Each independently supervised circuit shall include a discrete LCD readout to indicate disarrangement conditions per circuit.

E. The incoming power to the system shall be supervised so that any power failure must be audibly and visually indicated at the control panel and the remote annunciator. A green "power on" LED shall be displayed continuously while incoming power is present.

F. The system batteries shall be supervised so that a low battery condition or disconnection of the battery shall be audibly and visually indicated at the control panel.

G. The System Modules shall be electrically supervised for module placement. Should a module become disconnected the system trouble indicator shall illuminate and the audible trouble signal shall sound.

H. The system shall have provisions for disabling and enabling all circuits individually for maintenance or testing purposes.

I. There shall be a supervisory service initiating device for all handicapped refuge area occupancy devices. Device activation shall cause supervisory alarm (different tone then for system trouble or tamper switch supervisory) at the control panel and remote annunciator.

J. Activation of an air sampling smoke detector “Alert” or “Action” status or device “Trouble” shall initiate a supervisory alarm signal at the FACP. Supervisory condition shall activate an audible and visual alarm at the FACP.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Manufacturers: Simplex and Gamewell will not be accepted. Subject to compliance with requirements, provide fire alarm systems by the following:

1. Siemens Cerberus PRO
2. Notifier ONYX
3. Johnson Control IFC 2020
4. H.R. Kirkland Co, Inc. - Graphic/Directory Annunciators and Maps.

B. Fire Alarm Cable

1. West Penn

2. Belden
3. Annixter

2.2 FIRE ALARM AND DETECTION SYSTEMS:

A. General: Provide complete fire alarm products of types, sizes and capacities indicated, which comply with manufacturer's standard design, materials, components; construct in accordance with published product information, and as required for complete installation. Provide fire alarm and detection systems for applications indicated.

B. Wiring System Materials: Provide basic wiring materials which comply with Division-26 sections; "Raceways", Wires and Cables” and "Electrical Boxes and Fittings".

1. Provide wire and cable in accordance with requirements of manufacturer. Wire insulation shall comply with NEC Article 760.

2. Provide individual solid copper conductor sizes AWG #14, or larger.

3. Provide multiconductor cables for wire sizes smaller than AWG #16.

4. Provide conductors which are UL listed for the installation and location, and approved for fire alarm usage.

5. Initiating circuits shall be color coded red for positive, black for negative. Indicating circuits shall be color coded yellow for positive, brown for negative.

6. All conductors shall be numbered and their numbers shall correspond to the terminal block numbering they are connected to. Provide conductor wiring and terminal block numbering.

7. Wiring styles shall be as follows: Style B-IDC, Style 4-SLC, Style Y-IAC within buildings. Style D-IDC between buildings.

8. Existing notification appliances are to remain/be replaced. Intercept existing circuits, extend to new control panel, and terminate on new indicating circuit.

C. Power Requirements:

1. The control panel shall receive 120 VAC power via a dedicated circuit. The system shall include an integral, transient voltage surge suppression device (SPD) on the incoming 120- volt power. SPD device shall be UL 1449 rated for 380 volts/Type B.

2. The system shall be provided with sufficient battery capacity to operate the entire system upon loss of normal 120 VAC power in a normal supervisory mode for a period of 4/24/90 hours with 5/10/15 minutes of alarm operation at the end of this period. The system shall automatically transfer to the standby batteries upon power failure. All battery charging and recharging operations shall be automatic.

3. All external circuits requiring system operating power shall be 24 VDC and shall be individually fused at the control panel.

2.3 FIRE ALARM CONTROL PANEL:

A. Control Panel construction shall be modular with solid state, microprocessor based electronics that are compatible with current codes and current UL requirements. It shall display only those primary controls and displays essential to operation during a fire alarm condition. Keyboards or keypads shall not be required to operate the system during fire alarm condition.

B. A local audible device shall sound during Alarm, Trouble or Supervisory conditions. This audible device shall sound differently during each condition to distinguish one condition from another without having to view the panel. This audible device shall also sound during each keypress to provide an audible feedback to ensure that the key has been pressed properly.

C. The following primary controls shall be visible through a front access panel:

1. Eighty character liquid crystal display
2. Individual red system alarm LED
3. Individual yellow supervisory service LED
4. Individual yellow trouble LED
5. Green "power on" LED
6. Alarm acknowledge Key
7. Supervisory Acknowledge Key
8. Trouble Acknowledge Key
9. Alarm Silence Key
10. System Reset Key

D. The following secondary control switches and LED's shall be available behind an access door:

1. City disconnect/switch
2. Manual evacuation (drill)
3. Elevator bypass
4. Door holder release bypass
5. Smoke damper control switches

E. The control panel shall provide the following:

1. Setting of time and date
2. LED testing
3. Alarm, trouble, and abnormal condition listing
4. Enabling and disabling of each monitor point separately
5. Change in operator access levels
6. Walk Test enable and disable
7. Running diagnostic functions
8. Displaying software revision level
9. Displaying historical logs
10. Displaying card status
11. Point listing

F. For maintenance purposes the following lists shall be available from the point lists menu.

1. All points list by address
2. Monitor point list
3. Signal/speaker list
4. Auxiliary control list

5. Feedback point list
6. LED/switch status list
7. Device sensitivity points list

G. Scrolling thru menu options or lists shall be accomplished in a self-directing manner in which prompting messages shall direct the user. These controls shall be located behind an access door.

H. The Control Panel shall have a 2 line x 40 character liquid crystal display which shall be backlit for enhanced readability. So as to conserve battery standby power, it shall not be lit during an AC power failure unless an alarm condition occurs or there is keypad activity.

2.4 SYSTEM FRONT PANEL OPERATION AND CAPABILITIES:

A. Under normal condition the front panel shall display a "System is Normal" message and the current time and date.

B. Should an abnormal condition be detected the appropriate LED (Alarm, Supervisory or Trouble) shall flash. The panel audible signal shall pulse for alarm conditions and sound steady for trouble and supervisory condition.

C. The LCD shall display the following information relative to the abnormal condition of a point in the system.

1. 40 character custom location label
2. Type of device (i.e., smoke, pull station, water flow)
3. Point status (i.e., alarm, trouble)

D. Pressing the appropriate acknowledge button shall globally acknowledge every point in the list. These acknowledge functions may be pass code protected if the user has insufficient privilege to acknowledge such conditions. A message shall indicate insufficient privilege but allow the user to view the points without acknowledging them. Should the user have sufficient privilege to acknowledge, a message will be displayed informing the user that the condition has been acknowledged.

E. After all points have been acknowledged, the LED's shall glow steady and the audible alarm will be silenced. The total number of alarms, supervisory and trouble conditions shall be displayed along with a prompt to review each list chronologically. The end of the list shall be indicated by an end of list message "END OF LIST."

F. Alarm Silencing: Should the "Alarm Silence" button be pressed, all audible alarm signals shall cease operation.

1. Signals shall not be silenced during alarm silence inhibit mode.

G. System Reset: The SYSTEM RESET button shall be used to return the system to its normal state after an alarm condition has been remedied. The LCD display shall step the user thru the reset process with simple English Language messages.

1. Should an alarm condition continue to exist the message, "SYSTEM RESET IN PROGRESS" will be followed by the message "SYSTEM RESET ABORTED", and the system will remain in an abnormal state.

2. Should the Alarm Silence Inhibit function be active, the "SYSTEM RESET" key press will be ignored. The message, "SYSTEM RESET INHIBITED" will be displayed for a short time to indicate the action was not taken.

H. History Logging: The system shall be capable of logging and storing 300 events in an alarm log and 300 events in a trouble log. These events shall be stored in a battery protected random access memory. Each recorded event shall include the time and date of that event's occurrence.

I. Silent Walktest with History Logging (Field Selectable): The system shall be capable of being tested by one person. While in testing mode the alarm activation of an initiating device circuit shall be silently logged as an alarm condition in the historical data file. The panel shall automatically reset itself after logging of the alarm. The momentary disconnection of an initiating or indicating device circuit shall be silently logged as a trouble condition in the historical data file. The panel shall automatically reset itself after logging of the trouble condition. After testing is considered complete, testing data may be retrieved from the system in chronological order to ensure device/circuit activation.

1. Should the walk test feature be on for an inappropriate amount of time, it shall revert to the normal mode automatically.

2. The control panel shall be capable of supporting up to 8 separate testing groups whereby one group or points may be in a testing mode and the other (non-testing) groups may be active and operate as programmed per normal system operation.

3. Should an alarm condition occur from an active point, not in walk test mode, it shall perform operations described in Paragraph 1.6.

J. LED Supervision: All slave module LED's shall be supervised for burnout or disarrangement. Should a problem occur, the LCD shall display the module and LED location numbers to facilitate location of that LED.

K. System Trouble Reminder: Should a trouble condition be present within the system and the audible trouble signal silenced, the trouble signal shall resound at preprogrammed time intervals to act as reminder that the fire alarm system is not 100% operational. Both the time interval and the trouble reminder signal shall be programmable to suit the Owner's application.

L. Access Levels: There shall be four (4) access levels with level 4 being the highest level. Level 1 actions shall not require a passcode. Changes to passcodes shall only be made by authorized personnel. Access to a level will only allow the operator to perform all actions within that level plus all actions of lower levels, not higher levels. All keys, switches, and buttons shall have levels associated with them.

M. RS-232-C Output: Fire Alarm Control Panel shall be capable of operating remote CRT's and/or printers; output shall be ASCII format and EIA RS-232-C connection with an adjustable baud rate.

N. Auxiliary Devices:

1. Fire alarm auto dialer, call box, serial line, etc., and connections shall be coordinated and provided per owner requirements for interface to monitoring company or local fire department. Monitoring company shall be UL Listed. Provide one year of monitoring service with system.

2. The fire alarm panel shall be provided with "OPEN/CLOSE/AUTO" switches to allow manual operation of the exhaust smoke dampers on each floor.

O. Equipment Enclosures: Provide cabinets of sufficient size to accommodate the aforementioned equipment. Cabinet shall be equipped with locks and transparent door panel providing freedom from tampering yet allowing full view of the various lights and controls.

2.5 ADDRESSABLE COMMUNICATION NETWORK:

A. The system must provide communication with addressable initiating and control devices individually. Each of these devices will be individually annunciated at the control panel. Annunciation shall include the following conditions for each point:

1. Alarm
2. Trouble
3. Open
4. Short
5. Device missing/failed

B. All addressable devices shall have the capability of being disabled or enabled individually.

C. Up to 127 addressable devices may be multiplexed from a single pair of wires. Systems that require factory reprogramming to add or delete devices are unacceptable.

D. The communication format must be a completely digital poll/response protocol to allow t-tapping of the circuit wiring.

E. Each addressable device must be uniquely identified by an address code entered on each device at time of installation. The use of jumpers to set address will not be acceptable. Device identification schemes that do not use uniquely set addresses but relay on electrical position along the communication channel are unacceptable.

F. There shall be no limit to the number of detectors, zone adapter modules, or stations which may be activated or "IN ALARM" simultaneously.

G. All devices shall be supervised for trouble conditions. The system control panel will display the type of trouble condition in plain English. Should any device fail, it will not prevent the operation of other devices.

H. Spare capacity shall be provided to allow for 20 percent more addressable points to be added to the fire alarm system without adding additional components after system is complete.

2.6 ADDRESSABLE DEVICE TYPES:

A. General: Devices will be located as shown on the drawings. The location of addressable devices will be selected to optimize the system layout in order to provide the level of protection, zone identification and control as shown on the drawings.

B. Environmental Compensation Analog Sensors:

1. Smoke sensors shall be a smoke density measuring device having no self contained alarm set point. The alarm decision for each sensor shall be determined by the control panel. The control panel shall determine the condition of each sensor by comparing the sensor value to stored values. The control panel shall maintain a moving average of the sensors smoke chamber value. Systems that do not automatically maintain a constant smoke obscuration sensitivity for each sensor by compensating for environmental factors are deemed unacceptable.

2. The detector shall automatically indicate when an individual sensors needs cleaning. When a sensor's average value reaches a predetermined value, a "Dirty Sensor" trouble condition shall be audibly and visually indicated at the control panel. Additionally, the LED on the sensor base shall glow steady giving a visible indication at the sensor location. If a "Dirty Sensor" is left unattended, and its average value increases to a second predetermined value, an "Excessively Dirty Sensor" trouble condition shall be indicated at the control panel for the individual sensor.

3. The control panel shall automatically perform a daily self-test on each sensor. Checking the electronics in the sensor's base ensures the accuracy of the values being transmitted to the control panel. A sensor that fails the self-test will cause a "Self-Test Abnormal" trouble condition at the control panel. A sensor self-test which must be manually initiated by the operator shall not be acceptable.

C. Addressable Detector Bases: All addressable smoke and heat detector heads will plug into their bases. The base will contain electronics that communicate the detector status (normal, alarm, trouble) to the control panel over two wires. The same two wires shall also provide power to the base and detector. Detector heads (smoke or heat) must be interchangeable. Upon removal of the head, a trouble signal will be transmitted to the control panel.

D. Photoelectric Detector Head: Photoelectric type detectors shall be of the solid state photoelectric type and shall contain no radioactive material. They will use a pulsed infrared LED light source and be sealed against rear air flow entry. The detector shall fit into an addressable base that is common with both the heat and ionization type detectors.

E. Thermal Detector Head: Thermal detector heads must be UL listed. They will be a combination rate-of-rise and fixed temperature (135 degrees F) type, automatically restorable unless fixed temperature (190 degrees F.) type are specifically required. The detector shall fit into an addressable base that is common with both the photoelectric and ionization type detectors. Provide addressable module for automatic restoring detectors that are not addressable.

F. Pull Stations: Pull stations shall contain electronics that communicate the station’s status (alarm, normal) to the control panel over two wires which also provide power to the pull station. The address will be set on the station. They will be manufactured from high impact red Lexan. Station will mechanically latch upon operation and remain so until manually reset by opening with a key common to all system locks. Pull stations will be single/double action.

The front of the station is to be hinged to a backplate assembly and must be opened with a key to reset the station. The key shall be common with the control panels. The addressable manual station shall be Underwriters' Laboratories Inc. listed for operation with the control panel.

G. Duct Smoke Detectors: The detector shall be non-polarized 24VDC type which is compatible with the fire alarm panel and obtains its operating power from the supervisory current of the addressable loop. The detector head shall be the same as the addressable photoelectric detector heads used in the rest of the system. Provide duct detectors compatible with the air velocities within the duct to be installed (ie. for low velocity ducts, provide an in-duct style detector). It shall be possible to test the detector by use of a remote alarm test switch. The duct detector housing shall contain the addressable electronics necessary to communicate with the control panel. For maintenance purposes, it shall be possible to clean the sampling tubes by access through the detector housing. To minimize false alarms, voltage and transient suppression techniques shall be employed as well as automatic alarm verification circuitry and insect screens.

1. Each duct detector shall be provided with a remote alarm LED indicator and a key test switch. Plates shall be labeled with the name of the device/equipment served.
2. Interlock each fan with its associated duct detector.
3. Provide access door(s) for in-duct style duct detectors.

H. Adaptor Module: Adapter Modules shall be used for monitoring of waterflow, valve tamper, non-addressable detectors, and for control of smoke dampers, door holders, and other output control functions. Adapter Modules will be capable of mounting in a standard electric outlet box. Adapter Modules will include cover plates to allow surface or flush mounting. Adapter Modules will receive their 24VDC power from a separate two wire pair running from an appropriate power supply. There shall be two types of devices: Type 1; Monitor Adapter Modules - for conventional 2-wire thermal detector and/or contact device monitoring with Class B or Class A wiring supervision. Type 2; Control Adapter Modules - for signals, speakers, fire fighter phone jacks and other device control with Class B or Class A wiring supervision.

1. Provide modules as required for monitor of air sampling smoke detection points as follows:

   a. Fire Alarm
   b. Alert/Action
   c. Trouble

2. Provide modules as required for monitor and control of AC units such that the AC unit shall shut down upon detection of smoke at the unit or from any detector alarm within the space. Provide relays as required.

3. Provide modules as required to monitor existing hardwired zones. Existing zone quantities and configurations shall remain, unless otherwise indicated or shown on the plans.

2.7 ALARM SIGNAL DEVICES:

A. Fire Alarm Speaker Horn/Strobe Combination: Provide high impact resistant red LEXAN speaker horn/strobe combination devices as shown on the plans. Each assembly shall consist of two independent devices which are manufactured as compatible with each other and with the control equipment. Each assembly shall provide a terminal strip or wire leads for true in-out wiring connections. The strobe unit shall have a candela-second rating in compliance with ADA requirements and be rated at 24 VDC. Strobes shall be clear with red letters "FIRE" on two sides.

1. Provide wall mounting as shown on the plans. Verify manufacturer mounting requirements prior to rough in.

B. Individual Strobe Unit: Provide strobe units mounted where shown. Units shall match those used in the combination horn/strobe or speaker/strobe specified.

C. Where multiple strobe units are visible from a single location and the potential visible flash rate is 5 hz or more, provide synchronizing modules and strobes compatible for synchronizing as required. Provide additional wiring, conduit, and power supplies as necessary.

D. Speakers/Horns have been located on the drawings. It is the Contractor's responsibility to provide adequate coverage to achieve 70 dBA at all locations throughout the building. If locations shown are inadequate, show additional speakers /horns on shop drawing submittal. Additional speakers/horns will be added at no additional cost to the contract including conduit wiring, power supplies, etc.

E. Bells: Provide vibrating, direct current, 10 inches gong with strobe, suitable for exterior mounting; manufacturers standard bells at sprinkler entries.

2.8 AUXILIARY DEVICES/EQUIPMENT:

A. Magnetic Door Holder Devices: Provide door holders as shown on the plans. Release of doors occur on a verified alarm or after a general AC power failure in the building.

2.9 PRINTER AND VISUAL DISPLAY:

A. Provide a portable printer and visual display. Printer shall receive English language text from the fire alarm control panel in an industry standard ASCII format via an EIA RS-232-C connection.

B. All printed information shall include time and date.

C. The printer shall be 80 column and provide a hardcopy record of system events. Printer shall support the following features:

1. 120 VAC input power
2. Impact dot matrix
3. Cartridge type ribbon
4. Friction feed for cut forms
5. Tractor feed for continuous 9-1/2 inches wide pin-to-pin fanfold paper
6. UL 864 listed (UOXX)

D. A portable visual display with keyboard shall provide an English language display with time and date of system events. Display shall display a minimum of 24 lines of information. Information on the screen shall not scroll off until an acknowledge key is pressed. Display shall be easy-to-read, non-glare. Include a composite video output to drive slave CRT's. Keyboards shall provide the following functionality:

1. Acknowledgement of alarms, troubles and supervisory conditions.
2. Alarm silence
3. System reset
4. Time & Date
5. Alarm, Trouble, and Supervisory service condition summary screens.

2.10 GRAPHIC MAP:

A. Replace or modify the existing graphic map as required. The graphic map shall be a full color image on a white background mounted on a rigid backing and shall have an ultraviolet inhibitor laminated on the front. Provide a clear, anti-glare, LEXAN panel cover and mount map within a black anodized aluminum frame. Provide a concealed secured hanging system. Location of map shall be approved by the local Fire Marshall or the authority having jurisdiction. The graphic map shall include, but not be limited to, the following information:

1. Building outline, including address and adjacent streets.
2. All exterior doors.
3. Fire alarm control panel.
4. Sprinkler control valves.
5. Utility controls (electrical, natural gas, water).
6. Fire department connection.
7. Main area separations.
8. Compass direction reference (orient the map).
9. Map location ("YOU ARE HERE" with arrow).
10. Map location, fire alarm control panel, sprinkler valves and Fire Department connections must be highlighted in RED.
11. Zone area separations and designations.
12. Room names and numbers as labeled in the building.
13. Each duct detector; indicate HVAC unit designation and function (i.e., supply or return).
14. Legend of devices and other symbology.
15. Location of all individual devices.
16. Each fire detection and alarm device with addresses at each addressable device.

B. Provide building zone map showing each floor at each remote annunciator and include essential escape information unless otherwise specified.

C. Provide a building graphic map at the main control panel.

PART 3 EXECUTION

3.1 EXAMINATION:

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

3.2 IDENTIFICATION:

A. Provide electrical identification in accordance with Division-26 section on Electrical Identification.

3.3 INSTALLATION OF BASIC WIRING SYSTEM MATERIALS:

A. Provide raceways and supports per code.

B. Install wiring, raceways, and electrical boxes and fittings in accordance with Division 26 sections; “Raceways”, “Wires and Cables”, and “Electrical Boxes and Fittings”.

C. Install wiring in exposed ivory colored surface metal raceway where specifically noted as allowed on wall or ceilings.

D. Install wires and cables without splices. Make connections at terminal strips in cabinets or at equipment terminals. Make soldered splices in electronic circuits in control cabinets.

E. Protect all notification appliance circuits (NAC) devices by a 2-hour rated cable system or a 2-hour rated enclosure from the FACP until they enter the signaling zone that they serve.

F. Install all wiring for smoke control system in concealed metal raceway or exposed surface metal raceway where specifically noted as allowed.

3.4 INSTALLATION OF FIRE ALARM SYSTEMS:

A. Install fire alarm system as indicated, in accordance with equipment manufacturer's written instructions and complying with applicable portions of NEC and NECA's "Standard of Installation."

B. Wiring: Wiring of fire alarm system is not specifically detailed on drawings. Refer to the manufacturer's shop drawings for detailed wiring and connection information.

1. Complete wiring in accordance with manufacturer's requirements. Color code wiring and install per manufacturer's point-to-point wiring diagram. Determine exact number of wires for each fire area zone from number and types of devices installed. Connect each device with sufficient wiring to complete its intended operation.

2. Where there are a number of power requiring devices such as smoke detectors, fan relays, door holders and smoke damper operators installed in a circuit, group in numbers so power required does not exceed 80 percent of manufacturer's power supply rating. Provide extra wiring, or extra power supplies required to fulfill that requirement. In addition, provide extra or larger size wiring to alleviate voltage drops which makes device operate beyond voltage limits for which it was designed. Determine above with manufacturer's representative while equipment is being installed.

3. Where an existing system is present it shall remain in operation while the new system is being installed, tested, and accepted.

4. Mount audible and visual devices per Americans with disabilities Act (ADA) 1990 requirements.

3.5 FIELD QUALITY CONTROL:

A. Connection and Supervision: Make connections to panel under manufacturer's supervision. Run wiring to main terminal cabinet located adjacent to main fire alarm panel. Complete connections from this cabinet to panel utilizing Manufacturer's technicians.

B. Where work consists of additions or extensions to existing system, prior to starting work, establish that system is in proper working order. If condition exists which prevents normal operation of specified additions and extensions, bring this fact to Architect/Engineer's attention prior to doing work affecting existing system. Where work is done without such notification, it is assumed that connections have been made to a working system, and performance requirements and guarantee will apply to entire system.

C. System Test and Approval: Submit shop drawings for function and operation only, pre-approved by authority having local jurisdiction.

1. Prior to final acceptance of system, manufacturer shall, in presence of Contractor and Owner's Representative, test each sensing or detection and alarm device including devices and equipment interlocks such as equipment shutdown and smoke dampers. Schedule test with Architect/Engineer prior to testing.

2. The completed fire alarm system shall be fully tested in accordance with NFPA-72 by the contractor in the presence of the Owner's representative and the Local Fire Marshal. Upon completion of a successful test, the contractor shall so certify in writing to the owner and general contractor.

3. The contractor shall coordinate the testing of each fire alarm detector added or relocated under this project with the fire department and forward a completed checklist showing each detector operated properly and that proper indication of detector operation occurred at all control panels, annunciator panels, remote indicators, remote test switches, etc. In addition, proper interlocks, door release, etc. shall be documented with specific equipment affected listed by identifier.

4. Submit copy of test results in duplicate after signed by Owner's Representative to Architect/Engineer, Owner, and local Fire Protection Authority. Mount copy of inspection record in lexan enclosed frame assembly on control panel.

3.6 MAINTENANCE CONTRACT:

A. The equipment manufacturer shall make available to the owner a maintenance contract proposal to provide a minimum of two (2) inspections and tests per year in compliance with NFPA-72 guidelines.

3.7 WARRANTY:

A. The Contractor shall guarantee all equipment and wiring free from inherent mechanical and electrical defects for a period of one year from the date of acceptance as set forth in the general conditions.

3.8 OPERATING AND MAINTENANCE INSTRUCTIONS:

A. On completion of the work, the equipment manufacturer shall provide training for two maintenance personnel to a level equal to a "Factory-Certified Technician". The training shall be conducted at the vendor's local office or the Factory.

B. Provide three (3) copies of Operating and Maintenance Instructions in hardback, three-ring binders covering all equipment furnished. Manuals shall include the following information:

1. Name, address and telephone number of authorized service organization to be contacted for each equipment item. The local fire alarm supplier shall have a 24 hour telephone response service. An answering machine shall not be considered acceptable.

2. Parts list and wiring diagram, operating and maintenance instructions for each piece of equipment.
3. Shop drawings corrected to show as-built conditions.
4. Record of voltage sensitivity for each ionization detector head as recorded during final calibration.
5. All wiring diagrams shall show color coding of all connections and mounting dimensions of equipment.

3.9 PAINTING AND PATCHING:

A. Contractor shall paint all exposed conduit to match adjacent surfaces. All surfaces or finishes damaged as a result of this work shall be properly patched, painted and/or repaired by trained craftsmen of the trade involved.

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END OF SECTION 283111

SECTION 312219 – TOPSOIL

PART 1 - GENERAL

1.1 SUMMARY:

A. Work Includes: Furnishing, stockpiling and placing topsoil on a previously prepared subgrade.

B. Related Work:
1. Division 31 Section 21 20 00 “Earth Moving”
2. Division 32 Section 32 91 13 “Soil Preparation”
3. Division 32 Section 32 92 20 “ Native Seeding and Mulching”
4. Division 32 Section 32 93 00 “Trees, Plants, Groundcovers and Misc Landscape Items”
5. Division 32 Section 32 92 23 “Sodding”
6. Division 32 Section 32 96 45 “Riparian Planting”
7. Division 32 Section 32 96 53 “Emergent Wetland Plants”

1.2 QUALITY CONTROL: Submit soil analysis report for on-site and imported topsoil from the State University Agricultural Extension Service or other approved soil testing laboratory according to specifications outlined in Section 32 91 13 – Soil Preparation. Testing will be at the expense of the Contractor.

1.3 DELIVERY, STORAGE AND HANDLING: Do not deliver or place topsoil in a frozen, wet, or muddy condition.

PART 2 - MATERIALS

2.1 ON-SITE TOPSOIL: Topsoil previously stripped and stockpiled prior to earthwork operations.

2.2 IMPORTED TOPSOIL: All topsoil shall be a loam or sandy clay loam. At least ten (10) days prior to topsoil delivery, notify Project Manager of the source(s) from which topsoil is to be furnished, accompanied by a soil testing analysis/report. Topsoil shall be furnished by the Contractor and shall be a natural, friable soil representative of productive soils and shall meet the following conditions;

A. Imported topsoil shall be certified weed free and pest free.

B. It shall be obtained from the top twelve inches (12") of well drained areas.

C. Fertile, friable, loamy soil, reasonably free from subsoil, refuse, roots, heavy or stiff clay, stones larger than one inch (1”), coarse sand, noxious weed seed, sod, sticks, brush, litter, and other deleterious substances; suitable for the germination of seeds and the support of vegetative growth. The PH value shall be between 6.0 and 8.0.

D. Soil Texture: Sand, thirty to fifty percent (30% - 50%); silt, thirty to fifty percent (30% - 50%) percent; clay, fifteen to thirty-five percent (15% - 35%).

E. Additives: As determined by soil fertility tests.

F. Percent Organic Content: two point nine percent (2.9%) minimum five percent (5%) maximum.

G. Soluble Salts: Electric conductivity shall be less than three point three (3.3) mmhos/cm for dryland areas and less than five (5.0) mmhos/cm for irrigated lands.

PART 3 - EXECUTION

3.1 PLACING TOPSOIL:

A. Rip or scarify compacted subgrade to a 12" inch depth to bond topsoil to subsoil. Place topsoil to a minimum depth of 8" inches after settlement.
B. Topsoil shall be spread evenly and graded to elevations and slopes shown on drawings. Hand rake areas inaccessible to machine grading.
C. Utilize topsoil salvaged from on site as the top layer to the extent available. If sufficient on-site material is not available, the Contractor shall furnish and install imported topsoil in the manner described above. Topsoil shall mixed thoroughly with the salvaged topsoil prior to placement and amended after placement.

END OF SECTION 31 22 19

SECTION 328400 – PLANTING IRRIGATION

PART 1 - GENERAL

1.1 WORK INCLUDED - Work of this Section generally includes provisions for the installation of an underground landscape irrigation system including the following:

A. Static pressure verification and coordination of irrigation system installation with landscape material installation.

B. Trenching, stockpiling excavation materials, refilling and compacting trenches.

C. Complete irrigation system including but not limited to piping, backflow preventer assemblies, valves, fittings, heads, controllers and wiring, and final adjustments to insure complete coverage.

D. Water connections.

E. Replacement of unsatisfactory materials.

F. Clean-up, Consultant Reviews, and Project Acceptance.

G. Tests.

1.2 RELATED SECTIONS

A. Examine all sections related to project work.

1.3 REFERENCES

A. Perform Work in accordance with requirements of Conditions of the Contract and Division 01 - General requirements as well as provisions of all applicable laws, codes, ordinances, rules, and regulations.

B. Conform to requirements of reference information listed below except where more stringent requirements are shown or specified in Contract Documents.

1. American Society for Testing and Materials (ASTM) - Specifications and Test Methods specifically referenced in this Section.
2. Underwriters Laboratories (UL) - UL Wires and Cables.

1.4 QUALITY ASSURANCE

A. Installer Qualifications - Installer shall have had considerable experience and demonstrate ability in the installation of irrigation system(s) of specific type(s) in a

neat orderly, and responsible manner in accordance with recognized standards of workmanship. To demonstrate ability and experience necessary for this Project, and financial stability, submit if requested by Consultant, prior to contract award the following:

1. List of 3 projects completed in the last 2 years of similar complexity to this Project. Description of projects shall include:
   a. Name of project.
   b. Location.
   c. Owner.
   d. Brief description of work and project budget.

B. Special Requirements:

1. Work involving substantial plumbing for installation of copper piping, backflow preventer(s), and related work shall be executed by licensed and bonded plumber(s). Secure a permit at least 48 hours prior to start of installation.
2. Tolerances - Specified depths of mains and laterals and pitch of pipes are minimums. Settlement of trenches is cause for removal of finish grade treatment, refilling, compaction, and repair of finish grade treatment.
3. Coordination with Other Contractors - Protect, maintain, and coordinate Work with Work under other Section.
4. Damage To Other Improvements - Contractor shall replace or repair damage to grading, soil preparation, seeding, sodding, or planting done under other Sections during Work associated with installation of irrigation system at no additional cost to Owner.

C. Pre-Construction Conference - Contractor shall schedule and conduct a conference to review in detail quality control and construction requirements for equipment, materials, and systems used to perform the Work. Conference shall be scheduled not less than 10 days prior to commencement of Work. All parties required to be in attendance shall be notified no later than 7 days prior to date of conference. Contractor shall notify qualified representatives of each party concerned with that portion of Work to attend conference, including but not limited to Architect, Consultant, Contractor's Superintendent, and Installer.

1. Minutes of conference shall be recorded and distributed by Contractor to all parties in attendance within five days of conference.

1.5 SUBMITTALS - Prepare and make submittals in accordance with conditions of the Contract.

A. Materials List - Submit six copies of a complete materials list indicating manufacturer, model number, and description of all materials and equipment to be used. Show appropriate dimensions and adequate detail to accurately portray intent of construction.

B. Record Drawings (As-Builts):

1. At onset of irrigation installation secure Autocad files of original irrigation

design from Owner. At the end of every day, revise as-built prints for work accomplished that day in red ink. As-built field prints shall be brought up-to- date at the close of the working day every Friday by a qualified draftsperson. A print of record plan(s) shall be available at Project Site. Indicate zoning changes on weekly as-built drawings. Indicate non-pressure piping changes on as-built. Upon completion of Project, but prior to scheduling of substantial acceptance walk-through, submit for review a final set of as-built mylars and an Autocadd disk copy. Dimensions, from two permanent points of reference (building corners, sidewalk, road intersections or permanent structures), location of following items:

a. Connection to existing water lines.
b. Routing of sprinkler pressure lines (dimension maximum 100 feet along routing).
c. Sprinkler control valves.
d. Quick coupling valves.
e. Manual drains and stop and waste valves.
f. Drip line blow-out stubs.
g. Control wire routing if not with pressure mainline.
h. Gate valves.
i. Control wire and communication cable splices
j. Water meters
k. Locations of all sleeving including size, quantity and depth of sleeve
l. Flow sensors
m. Pressure regulating valves

2. Owner's Representative will not certify any pay request submitted by the Contractor if the as-built drawings are not current, and processing of pay request will not occur until as-builts are up-dated.

C. Operation Instructions - Submit 3 written operating instructions including winterization procedures and start-up, with cut sheets of products, and coordinate controller/watering operation instruction with Owner maintenance personnel.

1. Controller Charts:
   a. Do not prepare charts until Consultant has reviewed record (as-built) drawings.
   b. Provide one controller chart for each automatic controller installed.
      1) Chart may be reproduction of record drawing, if scale permits fitting of controller door. If photo reduction prints are required, keep reduction to maximum size possible to retain full legibility.
      2) Chart shall be blueline print of actual "as-built" system, showing area covered by that controller.
   c. Identify area of coverage of each remote control valve, using a distinctly different pastel color drawing over entire area of coverage.
   d. Following review of charts by Consultant, they shall be hermetically sealed between two layers of 20-mm thick plastic sheet
   e. Charts shall be completed and reviewed prior to final review of irrigation system.

1.6 DELIVERY, STORAGE, AND HANDLING - Deliver, unload, store, and handle materials,

packaging, bundling, products in dry, weatherproof, condition in manner to prevent damage, breakage, deterioration, intrusion, ignition, and vandalism. Deliver in original unopened packaging containers prominently displaying manufacturer's name, volume, quantity, contents, instructions, and conformance to local, state, and federal law. Remove and replace cracked, broken, or contaminated items or elements prematurely exposed to moisture, inclement weather, snow, ice, temperature extremes, fire, or jobsite damage.

A. Handling of PVC Pipe - Exercise care in handling, loading and storing, of PVC pipe. All PVC pipe shall be transported in a vehicle that allows length of pipe to lie flat so as not to subject it to undue bending or concentrated external loads. All sections of pipe that have been dented or damaged shall be discarded, and if installed, shall be replaced with new piping.

1.7 JOBSITE CONDITIONS:

A. Protection of Property:

1. Preserve and protect all trees, plants, monuments, structures, and paved areas from damage due to Work of this Section. In the event damage does occur, all damage to inanimate items shall be completely repaired or replaced to satisfaction of Owner, and all injury to living plants shall be repaired by Owner. All costs of such repairs shall be charged to and paid by Contractor.
2. Protect buildings, walks, walls, and other property from damage. Flare and barricade open ditches. Damage caused to asphalt, concrete, or other building material surfaces shall be repaired or replaced at no cost to Owner. Restore disturbed areas to original condition.

B. Existing Trees:

1. All trenching or other Work under limb spread of any and all evergreens or low branching deciduous material shall be done by hand or by other methods so as to prevent damage to limbs or branches.
2. Where it is necessary to excavate adjacent to existing trees use all possible care to avoid injury to trees and tree roots. Excavation, in areas where 2 inch and larger roots occur, shall be done by hand. Roots 2 inches or larger in diameter, except directly in the path of pipe of conduit, shall be tunneled under and shall be heavily wrapped with burlap to prevent scarring or excessive drying. Where a trenching machine is operated close to trees having roots smaller than 2 inches in diameter, wall of trench adjacent to tree shall be hand trimmed, making clean cuts through roots. Trenches adjacent to trees shall be closed within 24 hours, and when this is not possible, side of trench adjacent to tree shall be kept shaded with moistened burlap or canvas.

C. Protection and Repair of Underground Lines:

1. Request proper utility company to stake exact location (including depth) of all underground electric, gas, or telephone lines. Take whatever precautions are necessary to protect these underground lines from damage. If damage does occur, Utility Owner shall repair all damage. Contractor shall pay all

costs of such repairs unless other arrangements have been made.

2. Request Owner, in writing, to locate all private utilities (i.e., electrical service to outside lighting) before proceeding with excavation. If, after such request and necessary staking, private utilities that were not staked are encountered and damaged by Installer, Owner shall repair them at no cost to Installer. If Contractor damages staked or located utilities, they shall be repaired by Utility Owner at Contractor's expense unless other arrangements have been made.

D. Replacement of Paving and Curbs - Where trenches and lines cross existing roadways, paths, curbing, etc., damage to these shall be kept to a minimum and shall be restored to original condition.

1.8 WARRANTY/GUARANTY: - Manufacturer shall warrant materials against defects for a period of one year from date of Substantial Completion. Installer(s) shall guaranty workmanship for similar period.

A. Settling of backfilled trenches that may occur during guaranty period shall be repaired at no expense to Owner, including complete restoration of damaged property.

B. Expenses due to vandalism before substantial completion shall be borne by Contractor.

C. Owner will maintain turf and planting areas during warranty period, so as not to hamper proper operation of irrigation system.

1.9 MAINTENANCE:

A. Furnish the following maintenance items to Owner prior to final Acceptance:

1. Two Sets of special tools required for removing, disassembling, and adjusting each type of sprinkler head and valve supplied on this Project.
2. One eight foot valve key for operation of stop and waste valve.
2. Two six foot valve keys for operation of gate valves.
3. Two keys for each automatic controller.
4. Two quick coupler keys and two matching hose swivels for each type of quick coupling valve installed.
5. Two aluminum drain valve keys of sufficient length for operation of drain valves.

B. Winterization - include cost in bid for winterizing complete system at conclusion of sprinkling season (in which system received final acceptance) within 3 days notification by the Owner. System shall be voided of water using compressed air or similar method reviewed by Consultant. Reopen, operate, and adjust system malfunctions accordingly during April of following season within 3 days of notification by Owner.

1.10 EXTRA STOCK - In addition to installed system furnish the following items to Owner:

A. 10 Pop-up spray heads with nozzles of each type used.

B. 4 Rotor heads of each type used.

C. 30 Drip emitters of each type used.

D. 2 Single Station Decoders

PART 2 - PRODUCTS

2.1 MATERIALS:

A. General Piping:

1. Pressure Supply Line (from point of connection through backflow prevention unit) - Type "k" Hard Copper (3/4" – 2 1/2") and ductile iron (3" and larger).
2. Pressure Supply Lines (downstream of backflow prevention units) - Class 200 PVC BE (1" - 2 1/2") and Class 200 PVC RT (3" and larger, Purple.
3. Non-pressure Lines - Class 200 PVC BE, Purple.
4. PVC Sleeving - Class 160 PVC..
5. Drip Tubing - Toro Dura-Pol EHD 1645 3/4" with .050 inch wall thickness, Purple.
6. Emitter Tubing - As recommended by emitter manufacturer.

B. Copper Pipe and Fittings:

1. Copper Pipe - Type K, hard tempered.
2. Fittings - Wrought copper, solder joint type.
3. Joints - Soldered with solder, 45% silver, 15% copper, 16% zinc, and 24% cadmium and solidus at 1125~F and liquids at 1145~F.

C. Brass Pipe and Fittings:

1. Brass Pipe - 85% red brass, ANSI Schedule 40 screwed pipe.
2. Fittings - Medium brass, screwed 125-pound class.

D. Ductile Iron Pipe and Fittings:

1. Ductile Iron Pipe – Centrifugal cast ductile iron in metal molds for water pipe in accordance with ANSI C151 and AWWA A21.51 with asphaltic exterior coating and interior lining and coating in accordance with ANSI C151 and AWWA A21.
2. Fittings – Mechanical joint as supplied by the pipe manufacturer and rated for working pressures of 350 psi.
3. Gaskets – Furnish in accordance with ANSI C111 and AWWA A21.11.

E. Plastic Pipe and Fittings:

1. Identification Markings:
   a. Identify all pipe with following indelible markings:

1) Manufacturer's name.
2) Nominal pipe size.
3) Schedule of class.
4) Pressure rating.
5) NSF (National Sanitation Foundation) seal of approval.
6) Date of extrusion.

2. Solvent Weld Pipe - Manufactured from virgin polyvinyl chloride (PVC) compound in accordance with ASTM D2241 and ASTM D1784; cell classification 12454-B, Type 1, Grade 1.
   a. Fittings - Standard Wright, Schedule 40, injection molder PVC; complying with ASTM D1784 and D2466, cell classification 12454-B.
      1) Threads - Injection molded type (where required).
      2) Tees and ells - Side gated.
   b. Threaded Nipples - ASTM D2464, Schedule 80 with molded threads.
   c. Teflon Tape – All PVC male threaded fittings and nipples, excluding marlex fittings, shall receive wrapping of Teflon tape applied to threaded surfaces per pipe manufacturer's recommendations.
   d. Joint Cement and Primer - Type as recommended by manufacturer of pipe and fittings.
   e. Purple
3. Gasketed End Pipe - Manufactured from virgin Polyvinyl Chloride compound in accordance with ASTM D2241 and ASTM D1784; cell classification 1254- B, Type 1,Grade 1.
   a. Fittings and Services Tees (3" and larger) - Ductile iron, grade 70-55- 05 in accordance with ASTM A-536. Fittings shall have deep bell push-on joints with gaskets meeting ASTM F-477.
   b. Gaskets - Factory installed in pipe and fittings, having a metal or plastic support within gasket or a plastic retainer ring for gasket.
   c. Lubricant - As recommended by manufacturer of pipe fittings.
   d. Purple
4. Flexible Plastic Pipe - Manufactured from virgin polyethylene in accordance with ASTM D2239, with a hydrostatic design stress of 630 psi and designated as PE 2306.
   a. Fittings – Insert type manufactured in accordance with ASTM D2609; PVC Type 1 cell classification 12454-B.
   b. Clamps - All stainless steel worm gear screw clamps. Use 2 clamps per joint on 1-1/2 inch and 2 inch fittings.
   c. Purple

F. Drip and Sub-Surface Irrigation Systems:

1. Drip Tubing - Manufactured of flexible vinyl chloride compound conforming to ASTM D1248, Type 1, Class C, Category 4, P14 and ASTM D3350 for PE 122111C. Purple.
2. Fittings - Type and diameter recommended by tubing manufacturer.
3. Drip Valve Assembly - Type and size shown on Drawings.
   a. Wye Strainer - Plastic construction with 150 mesh nylon screen and 1/2 inch blowout assembly.
   b. Control Valve - 2 way, solenoid pilot operated type made of synthetic, non-corrosive material; diaphragm activated and slow closing. Include freely pivoted seat seal; retained (mounted) without

attachment to diaphragm.

c. Pressure Reducing Valve - Plastic construction as detailed.

d. Single station decoder

4. Emitters - Single port, pressure compensating, press on type.

5. Sub-Surface tubing - Size and type shown on Drawings; installed as detailed, purple.

G. Gate Valves:

1. Gate Valves for 3/4 inch through 2-1/2 Inch Pipe - Brass construction; solid wedge, IPS threads, and non-rising stem with wheel operating handle.

2. Gate Valves for 3 Inch and Larger Pipe - Iron body, brass or bronze mounted AWWA gate valves with a clear waterway equal to full nominal diameter of valve; rubber gasket or mechanical joint-type only. Valves shall be able to withstand a continuous working pressure of 200 psi and be equipped with a square operating nut and resilient wedge. Provide pipe restraints on gate valves 3 inches or larger as detailed.

H. Quick Coupling Valves - Brass two-piece body designed for working pressure of 150 PSI; operable with quick coupler. Equip quick coupler with locking purple rubber cover.

I. Valve Boxes:

1. Gate Valves, Quick Coupling Valves, Drain Valves, Drip Line Blow-out Stubs, and Wire Splice or Stub Box - Carson Brooks #910-10, box, with Purple T- Covers, as detailed.

2. 1 inch through 2 inch Control Valves, Master Valves, Pressure Regulating Valves and Communication Cable Splice box - Carson Brooks #1419-12 box with Purple T-Covers, as detailed.

3. Drip Valve Assemblies and Flow Sensors - Carson Brooks #1220-12 box, with Purple T-Covers, as detailed.

J. Electrical Control Wiring:

1. Low Voltage:

a. Electrical Control Wire - UFUL approved No. 14/14 (2-wire Paige #170116RB or as per manufactures requirements) direct burial copper wire to operate system as designed.

b. If multiple controllers are utilized, refer to wire routing plan for individual wire runs.

c. Control Wire connections and splices shall be made with 3M DBR-6 direct bury splice.

d. Loop five (5) feet minimum of 2-wire cable into all valve boxes.

e. If multiple controllers are utilized, each controller shall have its own 2-wire cable run, controllers cannot be connected with same 2-wire run.

2. High Voltage - Type required by local codes and ordinances, of proper size to accommodate needs of equipment serviced.

J. Automatic Controller (2-Wire) - Size and type shown on Drawings; mounted as detailed.

1. Single Station Decoders (2-Wire) - Size and type shown on Drawings; mounted as detailed.
   a. Install decoders and wire per manufacture recommendations and requirements.
   b. Grounding for all decoders and 2-wire cable, to be per manufactures recommendations and requirements. Minimum one grounding assembly per every 1000' of wire and/or every 12th decoder and at all ends of the wire runs.

L. Electric Control Valves - Size and type shown on Drawings having manual flow adjustment and manual bleed nut, purple options, single station decoder.

M. Sprinkler Heads - As indicated on Drawings. Fabricated riser units in accordance with details on Drawings - with fittings and nipples of equal diameter as riser inlet in sprinkler body. Purple caps.

N. Master Valve - Size and type indicated on Drawings.

O. Flow Sensor - Size and type indicated on Drawings.

P. Backflow Preventer - Size and type indicated on Drawings; Brass or iron construction with 150 psi working pressure.

PART 3 - EXECUTION

3.1 SITE CONDITIONS, LANDSCAPE PLAN REVIEW AND COORDINATION

A. Contractor will be held responsible for coordination between landscape and irrigation system installation. Landscape material locations shown on the Landscape Plan shall take precedence over the irrigation system equipment locations. If irrigation equipment is installed in conflict with the landscape material locations shown on the Landscape Plan, the Contractor will be required to relocate the irrigation equipment, as necessary, at Contractor's expense.

B. Contractor is responsible to notify Consultant of any field conditions that vary from the conditions shown on the Irrigation Construction Documents. If Contractor fails to notify Consultant of these conditions, Contractor will be held responsible for all costs associated with system adjustments required due to the change in field conditions.

3.2 STATIC PRESSURE VERIFICATION - Contractor shall field verify the static pressure at the project site, prior to commencing work or ordering irrigation materials, and submit findings, in writing, to Consultant. If Contractor fails to verify static water pressure prior to commencing work or ordering irrigation materials, Contractor shall assume responsibility for all costs required to make system operational and the costs required to replace any damaged landscape material. Damage shall include all required material costs, design

costs and plant replacement costs.

3.3 INSPECTION: - Examine areas and conditions under which Work of this Section is to be performed. Do not proceed with Work until unsatisfactory conditions have been corrected.

A. Grading operations, with the exception of final grading, shall be completed and approved by Owner before staking or installation of any irrigation system begins.

B. Underground Utilities shall be installed prior to installation of irrigation system. If irrigation installation takes place prior to utility installation, Contractor shall notify Owner of this condition in writing prior to commencement of irrigation installation.

3.4 PREPARATION:

A. Staking shall Occur as Follows:

1. Mark, with powdered lime, routing of pressure supply line and flag heads for first few zones. Contact Consultant 48 hours in advance and request review of staking. Proposed locations of all trees shall be field staked by Contractor and approved by Owner/Landscape Architect prior to Consultant review of irrigation staking. Consultant will advise installer as to the amount of staking to be prepared. Consultant will review staking and direct changes if required. Review does not relieve installer from coverage problems due to improper placement of heads after staking.
2. Contractor shall contact Consultant if field spacing varies by +/- 10% of the spacing shown on the irrigation plans. If Contractor fails to notify Consultant of variances exceeding 10%, Contractor assumes full responsibility for the costs associated with any required system modifications deemed necessary by the Consultant or Owner.
3. If Project has significant topography, freeform planting beds, or other amenities, which could require alteration of irrigation equipment layout as deemed necessary by Consultant, do not install irrigation equipment in these areas until Consultant has reviewed equipment staking.

B. Install sleeving under asphalt paving and concrete walks, prior to concreting and paving operations, to accommodate piping and wiring. Compact backfill around sleeves to 95% Modified Proctor Density within 2% of optimum moisture content in accordance with STM D1557.

C. Trenching - Trench excavation shall follow, as much as possible, layout shown on Drawing. Dig trenches straight and support pipe continuously on bottom of trench. Trench bottom shall be clean and smooth with all rock and organic debris removed.

1. Clearances:
   a. Piping 3 Inches and Larger - Make trenches of sufficient width (14 inches minimum) to properly assemble and position pipe in trench. Minimum clearance of piping 3 inches or larger shall be 5 inches horizontally on both sides of the trench.
   b. Piping Smaller than 3 Inches - Trenches shall have a minimum width of 7 inches.
   c. Line Clearance - Provide not less than 6 inches of clearance between

each line and not less than 12 inches of clearance between lines of other trades.

2. Pipe and Wire Depth:
   a. Pressure Supply Piping – 24-30 inches from top of pipe.
   b. PVC Sleeving – To match depth of sleeved material.
   c. Non-pressure Piping (rotor) - 18 inches from top of pipe.
   d. Non-pressure Piping (pop-up) - 12 inches from top of pipe.
   e. Control Wiring/Communication Cable - Side of pressure main or at 18 inch depth if installed in a separate trench with no mainline piping..
   f. Drip Tubing - 12 inches from top of pipe.
   g. Emitter Tubing (Micro-tubing) - 8 inches from top of pipe.
3. Boring will be permitted only where pipe must pass under obstruction(s) which cannot be removed. In backfilling bore, final density of backfill shall match that of surrounding soil. It is acceptable to use sleeves of suitable diameter installed first by jacking or boring, and pipe laid through sleeves. Observe same precautions as though pipe were installed in open trench.
4. Vibratory Plow - Non-pressure piping may be installed through use of vibratory plow method if consultant determines soil conditions are satisfactory for this method of installation. Vibratory plowing does not relieve installer of minimum pipe depths.

3.5 INSTALLATION - Locate other equipment as near as possible to locations designated. Consultant shall review deviations prior to installation.

A. PVC Piping - Snake pipe in trench as much as possible to allow for expansion and contraction. Do not install pipe when air temperature is below 40 degrees F. Place manual drain valves at low points and dead ends of pressure supply piping to insure complete drainage of system. When pipe installation is not in progress, or at end of each day, close pipe ends with tight plug or cap. Perform Work in accordance with good practices prevailing in piping trades.

1. Solvent Weld PVC Pipe - Lay pipe and make all plastic to plastic joints in accordance with manufacturer's recommendations.
2. Gasketed End Pipes:
   a. Lay pipe and make pipe to fitting or pipe to pipe joint, following OR70 recommendations (Johns-Manville Guide for Installation of Ring-Tite Pipe), or pipe manufacturer's recommendations.
   b. Construct concrete thrust blocks behind all gasketed fittings, tees, bends, reducers, line valves, and caps in accordance with pipe manufacturer's recommendations. Contact Consultant prior to placing thrust blocks, for observation of thrust block excavation and initial placement. Thrust block bearing surface shall be calculated based on tables below. All bearing surfaces shall be undisturbed soil:

THRUST BLOCK SIZING GUIDE:
Thrust developed per 100 PSI pressure (lbs. force) for various fitting configurations.

Pipe Size	Fitting 90° Elbow	Fitting 45° Elbow	Valves, Tees Dead Ends
3	1,000	600	800
4	1,800	1,100	1,300
6	4,000	2,300	2,900
8	7,200	4,100	5,100
10	11,200	6,300	7,900
12	16,000	9,100	11,300

Approximate bearing strength of typical soils.

Soil Type	lbs/ft 2
Mulch, Peat, etc.	0
Soft Clay	500
Sand	1,000
Sand And Gravel	1,500
Sand And Gravel With Clay	2,000
Sand And Gravel Cemented With Clay	4,000
Hard Pan	5,000

Example Calculation: 6 inch 90 degree elbow in sand and gravel soil Bearing Surface

Area (square feet) = 4,000 lbs / 1,500 lbs/ ft2
= 2.67 square feet bearing surface area on undisturbed soil

3. Flexible Plastic (Polyethylene) Pipe - Lay pipe and assemble fittings following manufacturer's recommendations.

B. Drip Tubing:

1. Make all fitting connections as per manufacturers recommendations.
2. Use only manufacturer provided or recommended hole punch when making penetrations in drip tubing for insert fittings. Use of any other hole punch shall be cause for immediate removal and replacement of all installed drip tubing.
3. Install drip line blow-out stubs at all dead ends of drip tubing.

C. Control Wiring:

1. Low Voltage Wiring:
The wire paths shall be twisted pair, solid-core, color-coded red/blue pairs with each conductor in a polyethylene jacket suitable for direct burial. The two-wire paths shall be UFUL approved No. 14/14 (2-wire Paige #170116RB).The two-wire paths may be spliced, or “teed”, permitting extensions of the path in multiple directions. In general, the distance from the controller to the end of any one end of a “tee” or wire run shall

not exceed the maximum for the gauge of wire, even if the total of all wire exceeds that number. For example, a path comprised of No.14/14 (rated for 10,000ft./3km) could extend 5000 ft./1.5km to a "tee" splice, and each arm of

the tee could extend an additional 5000 ft./1.5km. The total wire connected would equal 15,000 ft./4.5km, but the distance from the controller, to the end of each run, would be 10,000ft./3km or less, meeting the specification. All wire splices must be made in a valve box with DBR-6 or equal direct-burial waterproof connectors.

2. High Voltage Wiring for Automatic Controller:
   a. Provide 120 volt power connection to automatic controller.
   b. All electric work shall conform to local codes, ordinances, and authorities having jurisdiction. All high voltage electrical work shall be performed by licensed electrician.

D. Automatic Controller:

1. Install controller in accordance with manufacturer's instructions as detailed and where shown on Drawings.
2. Connect remote control valves to controller in numerical sequence as shown on Drawings.
3. Owner shall approve final location of controller prior to installation.
4. Each controller shall be a dedicated separate ground wire and grounding rod as detailed. Earth grounding shall be connected via a factory supplied copper ground lug inside the controller, for connection to earth ground hardware via 6 AWG (4mm dia.) copper wire (see ASIC Earth Grounding Guideline 100-2002 for details of earth grounding irrigation control systems available online at www.asic.org). Ground wire shall be extended underground, at right angles to any communications wiring, to approved direct burial earth grounding hardware at least 6 ft./2m from the controller location. Earth Ground shall be have an impedance of 10 Ohms or less, or shall meet the standards of the Earth Grounding Guideline cited above
5. All above ground conduit shall be rigid galvanized with appropriate fittings. All below ground conduit shall be schedule 40 PVC.

E. Electric Control Valves - Install cross-handle four inches below finished grade where shown on Drawings as detailed. When grouped together, allow minimum of 12 inches between valve box sides. Install each remote control valve in a separate valve box. Install valve box flush with grade or when present flush with surfacing material (rock mulch). When parallel to roadway, sidewalk or other permanent element or structure, control valve and box to be installed perpendicular to element or structure, spaced equally.

1. All connections in the two-wire paths (outside the controller enclosure) shall be made with 3M DBR-6 waterproof, strain-relieving direct burial connectors, or exact equals. Decoder output to solenoid connections shall be made with 3M DBY waterproof, strain-relieving connectors, or exact equals. No substitution of wire or wire connector specifications is permissible. All connections, tees, and splices shall be positioned in valve boxes for future location and service.
2. The installer shall provide adequate earth ground (not to exceed 10 Ohms, or in compliance with practices as defined in American Society of Irrigation Consultants Earth Grounding Guideline 100-2002, available at www.asic.org) and connect it to one of the decoder ground leads every 1000 ft.(330m), or every 12th decoder module, whichever is shorter. Minimum ground hardware shall be a 4" x 36" (100 x 915mm)

copper plate with at least 10AWG/2.5mm dia. copper wire. In high lightning areas, grounding may be increased to every 500 ft./150m or 10 decoders.
Ground connections from decoder ground lead to grounding hardware shall be made by joining the 12AWG (2mm dia.) decoder ground wire with a 10AWG (2.5mm dia.) solid copper lead in an approved wire nut of appropriate size, inserted in a DBR-6 waterproof direct burial connector, or with an approved wire clamp. Ground hardware shall extend at right angles from the two-wire red/blue path, and ground hardware shall be located at least 6ft./2m away from the two- wire path.

F. Quick Coupling Valves - Install quick couplers on swing-joint assemblies as indicated on construction details; plumb and flush to grade. Angled nipple relative to pressure supply line shall be no more than 45 degrees and no less than 10 degrees.

G. Drip and Sub-Surface Valve Assemblies - Install valve assembly as detailed

H. Drip Emitters - Stake all surface emitters as detailed and staked with acceptable tubing stakes.

I. Drain Valves - Install one manual drain valve on pressure supply line directly downstream of backflow preventer as detailed. Provide a three cubic foot drainage sump for drain valve as detailed.

J. Valve Boxes:

1. Install one valve box for each type of valve installed as detailed. Valve box extensions are not acceptable except for master valves and flow sensors. Install gravel sump after compaction of all trenches. Place final portion of gravel inside valve box after valve box is backfilled and compacted.
2. Brand controller letter and station number on lid of each valve box. Letter and number size shall be no smaller than 1 inch and no greater in size than 1 1/2 inches. Depth of branding shall be no more than 1/8 inch into valve box lid.

K. Gate Valves - Install where shown on Drawings as detailed.

L. Sprinkler Heads - Install sprinkler heads where designated on Drawings or where staked. Set to finish as detailed. Spacing of heads shall not exceed the maximum indicated on Drawing unless re-staked as directed by Consultant. In no case shall the spacing exceed maximum recommended by manufacturer. Install heads on swing joints or riser assemblies as detailed. Adjust part circle heads for proper coverage. Adjust heads to correct height after sod is installed. Plant placement shall not interfere with intended sprinkler head coverage, piping, or other equipment. Consultant may request nozzle changes or adjustments without additional cost to the Owner.

M. Backflow Preventer - Install as detailed at location designated on Drawings.

N. Master Valve - Install where shown on Drawings as detailed.

O. Flow Sensor - Install where shown on Drawings as detailed.

P. Backfilling - Do not begin backfilling operations until required system tests have been completed. Backfill shall not be done in freezing weather except with review by Consultant. Leave trenches slightly mounded to allow for settlement after backfilling is completed. Trenches shall be finish graded prior to walk-through of system by Consultant.

1. Materials - Excavated material is generally considered satisfactory for backfill purposes. Backfill material shall be free of rubbish, vegetable matter, frozen materials, and stones larger than 1 inch in maximum dimension. Do not mix subsoil with topsoil. Material not suitable for backfill shall be hauled away. Contractor shall be responsible for providing suitable backfill if excavated material is unacceptable or not sufficient to meet backfill, compaction, and final grade requirements.
2. Do not leave trenches open for a period of more than 48 hours. Open excavations shall be protected in accordance with OSHA regulations.
3. Compact backfill to 90% maximum density, determined in accordance with ASTM D155-7 utilizing the following methods:
   a. Mechanical tamping.
   b. Puddling or ponding. Puddling or ponding and/or jetting is prohibited within 20’-0" of building or foundation walls.

Q. Piping Under Paving:

1. Provide for a minimum cover of 18 inches between the top of the pipe and the bottom of the aggregate base for all pressure and non-pressure piping installed under asphaltic concrete or concrete paving.
2. Piping located under areas where asphalt or concrete paving will be installed shall be bedded with sand (a layer 6" below pipe and 6" above pipe).
3. Compact backfill material in 6" lifts at 90% maximum density determined in accordance with ASTM D155-7 using manual or mechanical tamping devices.
4. Set in place, cap, and pressure test all piping under paving, in presence of Owner prior to backfilling and paving operations.
5. Piping under existing walks or concrete pavement shall be done by jacking, boring, or hydraulic driving, but where cutting or breaking of walks and/or concrete is necessary, it shall be done and replaced at not cost to Owner. Obtain permission to cut or break walks and/or concrete from Owner.

R. Water Supply and Point of Connection - Water supply shall be extended as shown from water supply lines.

3.6 FIELD QUALITY CONTROL:

A. Flushing - After piping, risers, and valves are in place and connected, but prior to installation of sprinkler heads, quick coupler assemblies, and hose valves, thoroughly flush piping system under full head of water pressure from dead end fittings. Maintain flushing for 5 minutes through furthermost valves. Cap risers after flushing.

B. Pressure Testing - Conduct test in presence of Consultant. Arrange for presence of Consultant 48 hours in advance of testing. Supply force pump and all other test equipment. Compressed air shall not be used for pressure testing system.

1. After backfilling, and installation of all control valves, fill pressure supply line with water, and pressurize to 40 PSI over the designated static pressure or 120 PSI, whichever is greater, for a period of 2 hours.
2. Leakage, Pressure Loss - Test is acceptable if no loss of pressure is evident during the test period.
3. Leaks - Detect and repair leaks.
4. Retest system until test pressure can be maintained for duration of test.
5. Before final acceptance, pressure supply line shall remain under pressure for a period of 48 hours.
6. Pressure test shall be scheduled and passed prior to scheduling of Substantial Completion Walk-through.

C. Walk-Through for Substantial Completion:

1. Arrange for Consultant's presence 48 hours in advance of walk-through.
2. Entire system shall be completely installed and operational prior to scheduling of walk-through.
3. Operate each zone in its entirety for Consultant at time of walk-through and additionally, open all valve boxes if directed.
4. Generate a list of items to be corrected prior to Final Completion.
5. Furnish all materials and perform all work required to correct all inadequacies of coverage due to deviations from Contract Documents.
6. During walk-through, expose all drip emitters under operations for observation by Consultant to demonstrate that they are performing and installed as designed, prior to placing of all mulch material. Schedule separate walk-through if necessary.
7. Supply Consultant with prints of irrigation as-builts prior to scheduling substantial completion walk-through.

D. Walk-Through for Final Completion:

1. Arrange for Consultant’s presence 48 hours in advance of walk-through.
2. Show evidence to Consultant that Owner has received all accessories, charts, record drawings, and equipment as required before Final Completion walk-through is scheduled.
3. Operate each zone, in its entirety for Consultant at time of walk-through to insure correction of all incomplete items.
4. Items deemed not acceptable by Consultant shall be reworked to complete satisfaction of Consultant.
5. If after request to Consultant for walk-through for Final Completion of irrigation system, Consultant finds items during walk-through which have not been properly adjusted, reworked, or replaced as indicated on list of incomplete items from previous walk-through, Contractor shall be charged for all subsequent walk-throughs. Funds will be withheld from final payment and/or retainage to Contractor, in amount equal to additional time and expenses required by Consultant to conduct and document further walk- throughs as deemed necessary to ensure compliance with Contract

Documents.

3.7 ADJUSTING - Upon completion of installation, fine-tune entire system by adjusting patterns and break-up pins, and setting pressure reducing valves at proper and similar pressure to provide optimum and efficient coverage. Flush and adjust all sprinkler heads for optimum performance and to prevent overspray onto walks, roadways, and buildings as much as possible. Heads of same type shall be operating at same pressure +/- 10%.

A. If it is determined that irrigation adjustments will provide proper coverage, and improved water distribution as determined by Consultant, contractor shall make such adjustments prior to Final Acceptance, as directed, at no additional cost to Owner. Adjustments may also include changes in nozzle sizes, degrees of arc, and control valve throttling.

B. All sprinkler heads shall be set perpendicular to finish grade unless otherwise noted on Construction Plans or directed by Consultant.

C. Areas which do not conform to designated operation requirements due to unauthorized changes or poor installation practices shall be immediately corrected at no additional cost to the Owner.

3.8 CLEANING - Maintain continuous cleaning operation throughout duration of work. Dispose of, off-site at no additional cost to Owner, all trash or debris generated by installation of irrigation system.

END OF SECTION 02815

SECTION 329113 - SOIL PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

A. The Work of this Section includes preparation of soil for the purpose of amending the soil for irrigation sod and shrub bed areas.
   1. Soil preparation consists of ripping, fertilizing, soil conditioning and fine grading the topsoil. Soil preparation as specified herein MUST precede all seeding, sodding, and planting.

B. Related Work:
   1. Section 310000 - Earthwork
   2. Section 329220 - Native Seeding
   3. Section 329223 - Sodding
   4. Section 329300 - Plants

1.2 SUBMITTALS

A. Product Data: For each type of product.
   1. Include recommendations for application and use.
   2. Include test data substantiating that products comply with requirements.
   3. Include sieve analyses for aggregate materials.
   4. Material Certificates: For each type of soil amendment and fertilizer before delivery to the site, according to the following:
      a. Manufacturer's qualified testing agency's certified analysis of standard products.

B. Samples: For each bulk-supplied material, 1-gallon volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.

C. Quality Control Submittals:
   1. Certificates: State, Federal and other inspection certificates shall accompany invoice for materials showing source or origin. Submit to Owners Representative prior to acceptance of material.
   2. Material Analysis: Provide soil conditioner analysis performed no more than three months prior to delivery to site.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Fertilizer: Deliver inorganic or chemical fertilizer to site in original unopened containers bearing manufacturer’s guaranteed chemical analysis, chemical name, trade name, trademark and conformance to state law, bearing name and warranty of producer.

B. Notify Owners Representative of delivery schedule in advance so material can be inspected upon arrival at project site. Immediately remove unacceptable material from project site.

1.4 PROJECT/SITE CONDITIONS

A. General: Do not perform work when climate and existing site conditions will not provide satisfactory results.

B. Vehicular site access shall be limited to the area(s) indicated on the drawings or as defined by the Owners Representative.

C. Damage to lawns, natural areas, pavements, irrigation systems, underground utilities, and other improvements shall be repaired by the contractor at no additional cost to the Client.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.
   1. Laboratories: Subject to compliance with requirements:
      a. Colorado Analytical, Brighton, Colorado 303.659.2313.
   2. Multiple Laboratories: At Contractor's option, work may be divided among qualified testing laboratories specializing in physical testing, chemical testing, and fertility testing.

1.6 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency approved by the Owners Representative to perform preconstruction soil analyses on existing imported soil.

B. Imported Soil Analyses: For each unamended imported soil source, perform testing on soil samples and furnish soil analysis and a written report containing soil-amendment and fertilizer recommendations by a qualified testing agency performing the testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.
   1. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.

1.7 SOIL-SAMPLING REQUIREMENTS

A. General: Extract soil samples according to requirements in this article.

B. Sample Collection and Labeling: Have samples taken and labeled by Contractor in presence of Architect under the direction of the testing agency.
   1. Number and Location of Samples: Minimum of 8 representative soil samples from varied locations in Grant Frontier Park.
   2. Procedures and Depth of Samples: According to USDA-NRCS's "Field Book for Describing and Sampling Soils."
   3. Division of Samples: Split each sample into two, equal parts. Send half to the testing agency and half to Owner for its records.
   4. Labeling: Label each sample with the date, location keyed to a site plan or other location system, visible soil condition, and sampling depth.

1.8 TESTING REQUIREMENTS

A. General: Perform tests on soil samples according to requirements in this article.

B. Physical Testing:
   1. Soil Texture: Soil-particle, size-distribution analysis by one of the following methods according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods":
      a. Sieving Method: Report sand-gradation percentages for very coarse, coarse, medium, fine, and very fine sand; and fragment-gradation (gravel) percentages for fine, medium, and coarse fragments; according to USDA sand and fragment sizes.
      b. Hydrometer Method: Report percentages of sand, silt, and clay.
   2. Total Porosity: Calculate using particle density and bulk density according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
   3. Water Retention: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
   4. Saturated Hydraulic Conductivity: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods"; at 85% compaction according to ASTM D 698 (Standard Proctor).

C. Chemical Testing:
   1. CEC: Analysis by sodium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."
   2. Clay Mineralogy: Analysis and estimated percentage of expandable clay minerals using CEC by ammonium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 1- Physical and Mineralogical Methods."
   3. Metals Hazardous to Human Health: Test for presence and quantities of RCRA metals including aluminum, arsenic, barium, copper, cadmium, chromium, cobalt, lead, lithium, and vanadium. If RCRA metals are present, include recommendations for corrective action.
   4. Phytotoxicity: Test for plant-available concentrations of phytotoxic minerals including aluminum, arsenic, barium, cadmium, chlorides, chromium, cobalt, copper, lead, lithium, mercury, nickel, selenium, silver, sodium, strontium, tin, titanium, vanadium, and zinc.

D. Fertility Testing: Soil-fertility analysis according to standard laboratory protocol of SSSA NAPT NCR-13, including the following:
   1. Percentage of organic matter.
   2. CEC, calcium percent of CEC, and magnesium percent of CEC.
   3. Soil reaction (acidity/alkalinity pH value).
   4. Buffered acidity or alkalinity.
   5. Nitrogen ppm.
   6. Phosphorous ppm.
   7. Potassium ppm.
   8. Manganese ppm.
   9. Manganese-availability ppm.
   10. Zinc ppm.
   11. Zinc availability ppm.
   12. Copper ppm.
   13. Sodium ppm and sodium absorption ratio.
   14. Soluble-salts ppm.

15. Presence and quantities of problem materials including salts and metals cited in the Standard protocol. If such problem materials are present, provide additional recommendations for corrective action.
16. Other deleterious materials, including their characteristics and content of each.

E. Organic-Matter Content: Analysis using loss-by-ignition method according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."

F. Recommendations: Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy, viable plants indicated. Include, at a minimum, recommendations for nitrogen, phosphorous, and potassium fertilization, and for micronutrients.
1. Fertilizers and Soil Amendment Rates: State recommendations in weight per 1000 sq. ft.
2. Soil Reaction: State the recommended liming rates for raising pH or sulfur for lowering pH according to the buffered acidity or buffered alkalinity in weight per 1000 sq. ft.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.

B. Bulk Materials:
1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Do not move or handle materials when they are wet or frozen.
4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Install soil amendments as required in Section 310000 - Earthwork

B. Soil Conditioner:
1. Composted material shall consist of aged organic matter, free of weed or other noxious plant seeds, lumps, stones, or other foreign contaminants harmful to plant life, and having the following characteristics based on a nutrient test performed no longer than 3 months prior to its incorporation into the project:
   a. Organic matter: 25% maximum.
   b. Salt content: 5.0 mmhos/cm maximum.
   c. pH: 7.5, maximum.
   d. Carbon to nitrogen ratio shall be less than 20:1.
2. Mountain peat, aspen humus, gypsum and sand will not be accepted.

3. Acceptable product: Class I compost, such as Ecogro or Bio-comp, as produced by A1 Organics, Eaton, CO, or approved equal.
4. If a site is unable to be tilled as determined by the Owners Representative, then the following products shall be used as a soil conditioner:
    a. Organic slow release fertilizer (6-1-1), acceptable product: "Biosol" or approved equal.
    b. Granular Humic Acid soil conditioner, acceptable product: "Menefee Humate Soil Conditioner".
    c. Mycorrhizal Granular Inoculum. Acceptable product: "MycoApply Endo Granular.
    d. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per lb (0.45 kg) of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb (0.45 kg) of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.
    e. Mycorryzal Inoculant: AM-120, as manufactured by Reforestation Technologies International, locally available from Pawnee Buttes Seed, Greeley, CO, (970)356-7002.

2.2 SOIL CONDITIONER APPLICATION RATES

A. Soil Preparation in Planting Bed Areas:
1. Apply Soil Amendments at the following rates:
    a. Soil Amendments: Bid quantity to be four (4) cubic yards per one thousand (1,000) square feet, or per soil test recommendations.
    b. Fertilizer: Diamonium phosphate, bid quantity to be two (2) pounds of nitrogen per one thousand (1,000) square feet. Apply per manufactures recommendations for the type of planting area, or per soil test recommendations.
    c. Mycorrhizal inoculants: Apply per manufacturer's instructions and quantities appropriate to the planting type.
2. After applying Soil Amendments, thoroughly till area to depth of six inches (6") minimum by plowing, rototilling, harrowing, or disking until soil is well pulverized and thoroughly mixed. Soil Conditioners and Fertilizer shall be applied topically once final grade has been established and just prior to sodding or seeding.
3. Take soil samples, in similar locations to pre-construction testing, and test amended soil to ensure the final product meets the laboratory recommendations prior to planting.

2.3 FERTILIZER

A General:
1. Fertilizer shall conform to applicable State fertilizer laws. It shall be uniform in composition, dry, and free flowing, and shall be delivered to the site in the original, unopened containers, each bearing the manufacturer's guaranteed analysis. Fertilizer that has become caked or damaged will not be accepted.

B Turf Grass Lawns:
1. Diamonium phosphate (18-46-0). Nitrogen shall be composed of sulphur-coated Urea only. Provide in sufficient quantity to apply at the rate of 100 pounds nitrogen per acre, unless otherwise indicated by the soils tests.

B. Native Grass Areas:
1. Fertilizer shall not be applied to areas to receive native grass seeding.

2.4 HERBICIDE

A. Post Emergent Herbicide: Roundup (Glyphosate) or approved equal as manufactured by Monsanto Company or approved equal.

PART 2 - EXECUTION

2.1 EXAMINATION

A. General: Verify that existing site conditions are as specified and indicated on drawings before beginning work under this Section.
1. Grades: Inspect to verify rough grading is within +/- 0.1-foot of grades indicated and specified.
2. Damaged Earth: Inspect to verify that soil rendered unfit to support planting due to concrete, water, mortar, limewater or any other contaminant dumped on it has been removed and replaced with clean soil from a source approved by the Owners Representative.

B. Unsatisfactory Conditions: Report in writing to General Contractor with copy to Owners Representative.

C. Acceptance: Beginning of installation means acceptance of existing conditions by installer.

2.2 PREPARATION

A. Areas of Newly Placed Topsoil:
1. Protection:
a. Locate sewer, water, irrigation, gas, electric, phone and other pipelines or conduits and equipment prior to commencing work.
b. Contractor shall be responsible for proper repair to landscape, utilities, walls, pavements and other site improvements damaged by operations under this section.

B. Weed Control: Perform herbicide treatment over the entire area to be planted. Allow sufficient time to successfully complete the entire herbicide treatment process before proceeding with planting.
1. Herbicide treatment must be completed during the growing season.
2. Water surface 1/2" per week for two weeks prior to application if natural precipitation does not supply this amount to encourage weed seed germination.
3. Treat site with “Roundup” herbicide in accordance with manufacturer’s recommendations.
a. Two days after application water surface 1/2" per week if natural precipitation does not supply this amount to encourage weed seed germination.
b. Ten (10) days after the first “Roundup” application, review surface for evidence of plant growth.
c. Repeat steps 2, 3, 4, and 5, for a total of three (3) applications, until there is no evidence of plant growth after a 10-day period.
d. Obtain Owners Representative approval of surface conditions fourteen (14) days after last herbicide application.

e. Herbicide treatments beyond the 3 applications shall be considered additional to the contract and will be performed at the directed of the Owners Representative, after cost has been approved. Additional herbicide treatments required for imported topsoil shall be borne solely by the Contractor.
f. Remove plant debris from treated area.
g. Contact Owners Representative 48 hours in advance to review the site after each herbicide treatment. Do not proceed with additional planting until the results are approved and accepted by the Owners Representative.

4. Surface Grade: Establish grades as indicated on drawings, and as required in Division 31 Section "Earth Moving".
5. Remove weeds, debris, clods and rocks larger than one 1-inch. Remove and dispose of accumulated materials at direction of Owners Representative.
6. Erosion Control: Take measures and furnish equipment and labor necessary to control the flow, drainage and accumulation of water, and prevent soil erosion, blowing soil and accumulation of wind-deposited material on the site throughout duration of work. Insure that all excess water will run off the grades or will percolate within 12 hours.
7. Soil Testing: Soil amendments shall meet the minimum amounts as specified in Article 3.3, "Installation", below. Unless determined by the Owners Representative the Contractor shall be responsible for performing horticultural soil tests on a minimum of 4 current soil samples for each source of topsoil to be used in the project. Soil test will be used to determine the type and amount of soil organic amendment and fertilizer to be applied prior to seeding, sodding and planting. Locations for testing shall be approved by the Owners Representative.
8. Timing: Perform soil preparation just prior to planting operations and in accordance with final planting schedule. Coordinate with irrigation system installation to avoid damage.

C. Areas of Compacted Topsoil: Areas within the work limits or as defined on Drawings or by the Owners Representative that have vegetation that is sparse, stunted, anemic, weedy or was used as a construction staging, parking area and/or subjected to heavy use will require ripping to prepare the soil for revegetation. Scarify compacted soil to a 6-inch depth minimum to loosen topsoil.

D. Areas of Disturbed Topsoil: Areas disturbed but not severely compacted as determined by the Owners Representative, shall be deep tine aerated or shattered to prepare the soil for revegetation.

E. Areas of Undisturbed Natural Topsoil: Undisturbed sites that are or were supporting healthy plant growth need only surface seedbed preparation prior to sowing seed.

2.3 INSTALLATION

A. Install soil amendments as required in Section 310000 - Earthwork

B. Soil Preparation in Turf Grass Areas:
1. Apply amendments at the following rates:
a. Soil conditioner: 4 cubic yards per 1000 square feet. If a granular soil conditioner is being utilized the product shall be applied per the manufacturer's recommendations.
b. Diamonium phosphate: 2 pounds of nitrogen per 1000 square feet.

2. After applying soil conditioner and fertilizer, thoroughly till area to depth of 6-inches minimum by plowing, rototilling, harrowing, or disking until soil is well pulverized and thoroughly mixed.

C. Soil Preparation in Native Grass Areas and Shrub Bed Areas:
1. For bidding purposes only:
   a. Topsoil (on-site or imported): Two (2) cubic yards per thousand (1000) square feet.
2. For actual installation:
   a. Apply topsoil only as directed by per soils tests performed for the areas to be seeded at the rate of 2 cubic yards per 1000 square feet. Based on agronomy report, submit recommended amendment mixture and application rate to Engineer for approval prior to landscape operations begin.
3. Thoroughly till the area to depth of 6-inches minimum by plowing, rototilling, harrowing, or disking until soil is well pulverized and thoroughly mixed. If a soil conditioner is to be applied ensure that the product is spread evenly across the area to be seeded and mixed thoroughly into the soil.

D. Fine Grading in all Landscape Areas:
1. Complete fine grading for all areas prior to seeding or planting. Allow for natural settlement.
2. For ground surface areas surrounding buildings to be landscaped, maintain required positive drainage away from buildings.
3. Establish finish grades to within plus or minus 0.10-foot of grades indicated, in order to prevent “bird-baths” or ponding.
4. Finish grade shall be below edge of pavement prior to sodding, seeding or planting.
   a. Sodded Areas: Allow 1-1/2-inches for sod.
   b. Seeding Areas: Allow 1-inch for seed.
   c. Shrub Beds: Allow 4-inch for mulch.
5. Noxious weeds or parts thereof shall not be present in the surface grade prior to seeding.
6. Compaction of Surface Grade Prior to Landscape Installation: Firm, but not hard, 85% standard Proctor density within 2% optimum moisture.
7. Hand Raking:
   a. Turfgrass Lawn Areas: Prior to acceptance of grades, hand rake to smooth, even surface, free of debris, clods, rocks and organic matter greater than 1-inch.
   b. Native Seed Areas: Area shall not be raked smooth but left in a uniform condition after tilling. Rough raking may occur parallel to the contours only.
8. Restore planting areas to specified condition if eroded or otherwise disturbed after fine grading and prior to planting.

2.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Contractor is responsible for specified tests.

C. Perform the following tests:
1. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on

laboratory testing according to ASTM D 698. Space tests at no less than one for each 1000 sq. ft.

D. Soil will be considered defective if it does not pass tests.

E. Prepare test reports.

F. Label each sample and test report with the date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

G. Inspection: Provide notice to the Owners Representative requesting inspection at least 7 days prior to anticipated date of completion.

H. Deficiencies: The Owners Representative will specify deficiencies to Contractor who shall make satisfactory adjustments and shall again notify Owners Representative for final inspection.

2.5 CLEANING

A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.

B. Remove debris and excess materials from site. Clean out drainage inlet structures. Clean paved and finished surfaces soiled as a result of work under this Section, in accordance with Section 208 of the General Specifications or as directed by the Owners Representative.

2.6 PROTECTION

A. Provide and install barriers as required and as directed by Owners Representative to protect completed areas against damage from pedestrian and vehicular traffic until acceptance by Client.

B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:
   1. Storage of construction materials, debris, or excavated material.
   2. Parking vehicles or equipment.
   3. Vehicle traffic.
   4. Foot traffic.
   5. Erection of sheds or structures.
   6. Impoundment of water.
   7. Excavation or other digging unless otherwise indicated.

C. If planting soil or subgrade is overcompacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by Owners Representative and replace contaminated planting soil with new planting soil. Hidden Text

END OF SECTION 32 91 13

SECTION 329223 - SODDING

PART 1 - GENERAL

1.1 SUMMARY

A. The Work of this Section includes furnishing and installation of bluegrass sod, and maintenance of sodded areas.

B. Related Sections:
   1. Section 328400 – Planting Irrigation
   2. Section 329113 - Soil Preparation
   3. Section 329300 - Plants

1.2 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

D. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

E. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.

F. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

G. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

H. Weeds: Including but not limited to Goathead, Bindweed, Twitch, Dandelion, Jimsonweed, Knapweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Weed, Bent Grass, Wild Garlic, Perennial Sorrel, and Broom Grass.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.
   1. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to this Project.

B. Sod Certificates:
   1. State, Federal and other inspection certificates for sod shall be provided to the Owners Representative a minimum of 10 working days prior to anticipated date of sod delivery.
   2. Submit a list of varieties contained in the sod, and include the source and origin for approval by the Owners Representative.

C. Qualification Data: For qualified landscape Installer.

D. Product Certificates: For soil amendments and fertilizers, from manufacturer.

E. Material Test Reports: For existing in-place surface soil.
   1. Soil analysis for each topsoil to be used.
   2. Analysis for manufactured topsoil.
   3. Analysis for each soil amendment.
   4. Analysis for each amended planting soil.

F. Analysis and standards: Wherever applicable, for non-packaged materials, provide two copies of analysis by recognized laboratory made in accordance with methods established by the Association of Official Agriculture Chemists.

G. Planting schedule: Submit in writing two copies of proposed planting schedule, indicating dates for topsoil placing, site preparation, herbicide treatments, soil preparation, sodding, seeding, and coordination with plant procurement, planting soil preparation, plant delivery and planting. Schedule all Work during specified planting seasons. Once accepted, revise dates only as approved in writing, after documentation of reasons for delays.

H. Maintenance Instructions: Recommended procedures for maintenance of turf and dryland grasses during a calendar year. Submit before expiration of required initial maintenance periods.

I. Contract Closeout Submittals:
   1. Operating and Maintenance Data: At completion of work, submit one digital copy and two hard copies to the Owners Representative in accordance with Division 01 Section "Contract Closeout'. Include directions for irrigation, aeration, mowing, fertilizing and spraying as required for continued and proper maintenance through full growing season and dormant period.
   2. Warranty for Turfgrass Sod Areas: At completion of work, furnish written warranty to Owners Representative based upon specified requirements.

J. The Owners Representative reserves the right to reject the sod at any time prior to acceptance and that fails to meet specification requirements.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turf and dryland grass establishment.
   1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
   2. Experience: Five years' experience in turf installation in addition to requirements in Division 01 Section "Quality Control."
   3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
   4. Sod Producer: Company specializing in sod production and harvesting with minimum 5 years' experience, and certified by the State of Colorado Department of Agriculture.
   5. Personnel Certifications: Installers shall have certification the following categories from the Professional Landcare Network:
      a. Certified Landscape Technician - Exterior, with installation maintenance irrigation specialty area(s), designated CLT-Exterior.
   6. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.
   7. Pesticide Applicator: State licensed, commercial.

B. Soil-Testing Laboratory Qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

C. Soil Analysis: See Section 329113 - Soil Preparation.

D. Preinstallation Conference: Conduct conference at Project site to coordinate the process with other trades, to coordinate equipment movement within planting areas and to avoid soil compaction, to review proposed methods of installation, performance criteria, and maintenance procedures. Review underground utility location maps and plans. This meeting shall be coordinated by the Contractor, and comply with requirements in Division 1.

E. Standards: All materials and methods used during this portion of the work shall meet or exceed applicable federal, state, county, and local laws and regulations. All sod shall be free from insects and disease. Species shall be true to their scientific name as specified.

F. Materials: The Contractor shall submit to the Owners Representative for approval a complete list of all materials to be used during this portion of the work prior to delivery of any materials to the site. Include complete data on source, amount and quality. This submittal shall in no way be construed as permitting substitution for specific items described on the plans or in these specifications unless approved in writing by the Owners Representative

G. Source Quality Control:
   1. Sod Materials: Subject to inspection and acceptance. The Owners Representative reserves the right to reject at any time or place prior to acceptance, any work and sod which in the Owners Representative's opinion fails to meet these specification requirements.
   2. Inspection will be made periodically during sodding, at completion and at end of warranty period by the Owners Representative. Primarily for quality; however, other requirements are not waived even though visual inspection results in acceptance.
   3. Promptly remove rejected sod from site.

H. Sod Standards:
   1. Sod shall consist of healthy, thick turf having undergone a program of regular fertilization, mowing and weed control; free of weeds; uniform in green color, leaf texture and density; healthy, vigorous root system; inspected and found free of disease, nematodes, pests and pest larvae by the State Department of Agriculture.
   2. Each piece of Sod shall consist of a sandy-loam soil base that will not break, crumble or tear during sod installation.
   3. Sod thickness shall be a minimum 3/4-inch thick, excluding top growth and thatch.
   4. Thatch layer shall not exceed 1/2-inch, uncompressed.
   5. Sod shall be delivered and installed within 24 hours of being cut.

1.5 DELIVERY, STORAGE AND HANDLING

A. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver on pallets properly loaded on vehicles with root system protected from exposure to sun, wind, and heat in accordance with standard practice. Sod that has been damaged by poor handling or improper storage is subject to rejection by the Owners Representative.
   1. Protect from dehydration, contamination, freezing and heating at all times. Keep stored sod moist and under shade or covered with moistened burlap.
   2. Do not drop sod rolls from carts, trucks or pallets.
   3. Do not deliver more sod than can be installed within 24 hours.

B. Fertilizer: Deliver inorganic or chemical fertilizer to site in original unopened container bearing manufacturer’s guaranteed chemical analysis, name, trade name, trademark, warranty and conformance to state law.

C. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.
   4. Fertilizer: Deliver inorganic or chemical fertilizer to site in original unopened container bearing manufacturer’s guaranteed chemical analysis, name, trade name, trademark and conformance to state law, and bearing name and warranty of producer.

D. Material will be inspected upon arrival at project site. Owners Representative will reject any opened or unacceptable materials as described above.

E. Immediately remove unacceptable material from job site.

1.6 PROJECT/SITE CONDITIONS

A. Work scheduling: Proceed with and complete landscape work as rapidly as portions of the site become available, working within the specified planting season and approved schedule.

B. Vehicular accessibility on site shall be as directed by Owners Representative. Repair damage to prepared topsoil and existing surfaces, caused by vehicular access and movement during work under this section, to original condition at no additional cost to the Client.

C. Install sod between April 15 and October 1 or when irrigation is available for 21 days per Denver Water's guidelines for sod establishment.

D. Schedule work for periods of favorable weather. Do not install sod on saturated or frozen soil. The Owners Representative reserves the right to deny sod installation on days that are deemed to be unfavorable for installation.

E. Existing conditions:
   1. Existing Plants: Install sod only after all other landscape and irrigation items have been installed and accepted by the Owners Representative
   2. Utilities: Determine location of underground utilities. Perform work in a manner to avoid possible damage. Hand excavate, as required.
   3. Excavation: Maintain grade stakes set by others until removal is mutually agreed upon by parties concerned. When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, noxious materials or obstructions, notify Owners Representative before planting.
   4. If weeds are present on site, treat with herbicide prior to preparing soil for installing sod as specified in this or other Sections.

F. Coordination:
   1. Coordinate with construction of utilities on site. Do not begin placing topsoil and sod until underground work is completed in the area.
   2. Coordinate sodding with Contractor(s) approved schedule. Limit construction access to areas where topsoil has been placed if placement is completed more than 3 days prior to commencement of landscaping in the area. Limit fine grading to areas that can be prepared for planting within 24 hours after fine grading.
   3. Coordinate with Contractors work requiring access to site over sodded areas.
   4. Coordinate with installation of underground irrigation system.

1.7 WARRANTY

A. Warranty for Sod Areas: Warrant areas in sod to be in a healthy, vigorous growing condition, and for consistency and completion of coverage for a period of one year from date of Substantial Completion as a full stand of grass. Re-sod any spots larger than 12" square where sod has failed to establish, as defined in this Section. Continue this procedure until a successful stand of grass is growing and accepted by the Owners Representative.
   1. During the original warranty period, re-sod at once with comparable blend/mix, those areas that have failed to achieve a stand of grass or which in the Owners Representative's opinion are unhealthy.
   2. Re-sodding will not be allowed in any season considerable unfavorable for sodding by the Owners Representative

B. Re-sod in a manner to achieve quality as originally specified per the Owners Representative's direction

PART 2 - PRODUCTS

2.1 MATERIALS

A. Soil Preparation: See Section 329113 - Soil Preparation.

B. Sod:
   1. Colorado grown Kentucky Bluegrass blend Reveille Hybrid Bluegrass available thru Graff's Turf Farm 800.280.8873 or approved equal.
   2. Colorado grown Bandera Hybrid Bluegrass blend having a healthy, vigorous root system.
   3. Sod to be produced in accordance with requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in TPI's "Guideline Specifications to Turfgrass Sodding."
   4. Harvesting: Sod shall be fertilized 2–3 weeks prior to harvesting. Mow sod to a height of 1-1/2 inches before the sod is lifted. Sod shall be harvested in rolls, and shall not be cut more than 24 hours prior to planting.
   5. Size: Machine cut to a minimum pad thickness of 3/4 inch, excluding top growth and thatch. Provide sod of uniform pad sizes 18" maximum width by 24" minimum length, with maximum 5% deviation in either length or width. Broken pads or pads with uneven ends will not be acceptable. Sod pads incapable of supporting their own weight when suspended vertically from upper 10% of pad will be rejected. Sod which has dried out, sod with adhering soil which breaks, tears, or crumbles away will not be accepted. Sod cut for more than twenty-four (24) hours will not be accepted.
   6. Plastic netting: Sod to be free of plastic netting used during establishment by sod grower.

C. Fertilizer: Inorganic mixture with following chemical composition: (20-5-10) with 50% sulfur coated urea (no iron), or as recommended by testing lab based on soil sample results.

D. Water: Contractor to utilize the existing irrigation system and or quick coupler(s) when available. If irrigation or quick coupler(s) are not available, then the contractor is responsible for watering. Refer to Section 328400 – Planting Irrigation. Water shall be free of substances that may be harmful to sod growth. Hoses and other watering equipment necessary to water the sod to be furnished by Contractor.

2.2 HERBICIDES

A. General: Herbicide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted herbicides unless authorized in writing by Owners Representative and authorities having jurisdiction.
   1. Pre-Emergent Herbicide (Selective and Non-Selective): Use only with approval by Owners Representative. Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
   2. Post-Emergent Herbicide. "Round-up" by Monsanto, or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.
   1. Verify that finish grades are consistent with the slopes and grades indicated on the Drawings. Verify grades are in conformance with Division 31 Section "Earth Moving".
   2. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
   3. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
   4. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
   5. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected and approved by the Owners Representative.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Engineer and replace with new planting soil.

D. Acceptance: Beginning of installation means acceptance of existing conditions by the Contractor.

3.2 PREPARATION

A. Work notification: Notify the Owners Representative at least 7 working days prior to start of sodding operations.

B. Limit turf subgrade preparation to areas that can be sodded within 24 hours.

C. Newly Graded Subgrades: Prepare soil as required by Section 329113 - Soil Preparation.

D. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
   1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
   2. Loosen surface soil to a depth of at least 8 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches (100 mm) of soil. Till soil to a homogeneous mixture of fine texture.
   3. Remove stones larger than ½ inch in any dimension and sticks, roots, trash, and other extraneous matter.
   4. Legally dispose of waste material, including grass, vegetation, and turf, off property.

E. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

F. Verify that all areas are graded to drain at a minimum of 2% or as indicated on the drawings. Verify that subsurface drainage system and drain inlets if any, are operative.

G. Verify that irrigation system is operable and provides adequate coverage prior to planting.

H. Adjustment: Adjust irrigation heads to proper watering height according to depth of sod material but lower than compacted blade height to enable lawn mowers to cut grass freely without damage to the sprinkler system.

I. When completed, the soil shall be firmed by float dragging, followed by steel raking, to provide for the proper sodded subgrade. The sod bed shall be totally free from rock or clay clods over 1/2-inch in diameter.

J. Repair: Re-establish grade and specified conditions to damaged sod areas prior to placing sod.

3.3 INSTALLATION

A. Sodding:
1. Sod within 24 hours after preparation of bed.
2. If plastic netting is present within sod, remove all netting during sod installation.
3. Subgrade on which sod is laid shall be slightly moist during installation.
4. Lay sod with longest dimension parallel to contours and in continuous rows.
5. Tightly butt ends and sides of sod together. Stagger and compact vertical joints between sod strips.
6. Sod shall not be overlapped or stretched during placement. Exposed joints due to shrinkage will require replacement of sod in affected areas.

B. Topsoil: Where new sod abuts an existing turf area topsoil shall be placed along seams and or joints to provide a smooth transition.

C. Rolling: Sod shall be rolled after installation to ensure proper contact with the subgrade, and to ensure tight joints between adjacent pieces. Sod shall be moist prior to rolling. Once rolling is complete additional watering shall occur. Roller shall weigh 100 pounds.

D. Drainage: Contractor shall ensure that finished areas are graded so that positive drainage of storm and irrigation water is achieved.

E. Water thoroughly with a fine spray as laying progresses and immediately after planting. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches (38 mm) below sod.

F. After sod and soil have dried, roll sodded areas to ensure a good bond between sod and soil and to remove minor depressions and irregularities. Roller shall not exceed 100 pounds.

3.4 FERTILIZING

A. Distribute (20-5-10) fertilizer uniformly at the rate of 5 pounds of material per 1,000 square feet, 1 pound of actual nitrogen per 1,000 square feet or 60 days after initial sodding operations and every 60 days thereafter until Final Acceptance of project by the Owners Representative.

3.5 PROTECTION

A. Protect existing utilities, paving and other facilities from damage caused by sodding operations, Contractor shall repair any damage at no additional cost to the Client.

B. Restrict vehicular and pedestrian traffic from sodded areas until grass is established. Erect signs and barriers as required or directed by the Owners Representative at no additional cost to the Client.

C. Locate, protect and maintain the irrigation system during sodding operations. Repair irrigation system components damaged during sodding operations shall be replaced or repaired to current City irrigation standards at Contractor's expense.

D. Erosion Control: Take measures and furnish equipment and labor necessary to control and prevent soil erosion, blowing soil and accumulation of wind-deposited materials on the site throughout the duration of work.

3.6 CLEANING

A. General: Provide and install barriers as required and as directed by Owners Representative to protect sodded areas against damage from pedestrian and vehicular traffic until Final Acceptance.

END OF SECTION 32 92 23

SECTION 329300 - PLANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plants.
2. Tree-watering devices.
3. Landscape edgings.

1.2 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

C. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329113 "Soil Preparation" for drawing designations for planting soils.

D. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples of each type of mulch.

1.5 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owners Representative for maintenance of plants during a calendar year.

1.7 QUALITY ASSURANCE

A. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

1. Pesticide Applicator: State licensed, commercial.

B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

B. Handle planting stock by root ball.

C. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F (16 to 18 deg C) until planting.

D. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1.9 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

1. Failures include, but are not limited to, the following:

   a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner.
   b. Structural failures including plantings falling or blowing over.

2. Warranty Periods: From date of Substantial Completion.

   a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
   b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

B. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

2.2 FERTILIZERS

A. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.

1. Size: 5-gram tablets.
2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

2.3 MULCHES

A. Mineral Mulch: Rounded riverbed gravel or smooth-faced stone.
1. Size: Rounded riverbed rock shall be screened 1-1/2” to 2” diameter, natural color range of greys and browns.
2. Type: Cobble shall be 6” to 8” diameter, smooth and with a minimum (5% maximum) of fractured pieces, natural color range of greys and browns.

2.4 WEED-CONTROL BARRIERS

A. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. (101g/sq. m) minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally encountered chemicals, alkalis, and acids.

B. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd. (162 g/sq. m).

2.5 PESTICIDES

A. General: Pesticide registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required

for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

2.6 LANDSCAPE EDGINGS

A. Steel Edging: Refer to plans for detail.

PART 3 - EXECUTION

3.1 PLANTING AREA ESTABLISHMENT

A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 - Soil Preparation.

B. Placing Planting Soil: Place and mix planting soil in-place over exposed subgrade.

C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.2 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits.

1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
2. Excavate approximately three times as wide as ball diameter.
3. Excavate at least 12 inches (300 mm) wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
4. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.

B. Backfill Soil: Subsoil and topsoil removed from excavations may be used as backfill soil unless otherwise indicated.

3.3 TREE, SHRUB, AND VINE PLANTING

A. Inspection: At time of planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Set each plant plumb and in center of planting pit or trench with root flare 1 inch (25 mm) above finish grades.

1. Backfill: Planting soil for trees, use excavated soil for backfill.
2. Balled and Burlapped Stock: After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
3. Container-Grown Stock: Carefully remove root ball from container without damaging root ball or plant.
4. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
5. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole.

6. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.4 TREE, SHRUB, AND VINE PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.

C. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.

D. Do not apply pruning paint to wounds.

3.5 GROUND COVER AND PLANT PLANTING

A. Set out and space ground cover and plants other than trees, shrubs, and vines as indicated on Drawings in even rows with triangular spacing.

B. Use planting soil for backfill.

C. Dig holes large enough to allow spreading of roots.

D. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

E. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

F. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.6 PLANTING AREA MULCHING

A. Install weed-control barriers before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 6 inches (150 mm) and secure seams with galvanized pins.

B. Mulch backfilled surfaces of planting areas and other areas indicated.

1. Trees in Turf Areas: Apply organic mulch ring of 3-inch (75-mm) average thickness, with 24-inch (600-mm) radius around trunks or stems. Do not place mulch within 3 inches (75 mm) of trunks or stems.

3.7 EDGING INSTALLATION

A. Concrete Edging: Install concrete edging where indicated according to plans and details.

3.8 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings.

B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

D. Apply pesticides and other chemical products and biological control agents according to authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's Representative operations and others in proximity to the Work. Notify Owners Representative before each application is performed.

E. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

F. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

3.9 MAINTENANCE SERVICE

A. Maintenance Service: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:

1. Maintenance Period for Trees and Shrubs: 12 months from substantial completion
2. Maintenance Period for Ground Cover and Other Plants: 12 months from substantial completion.

END OF SECTION 329300